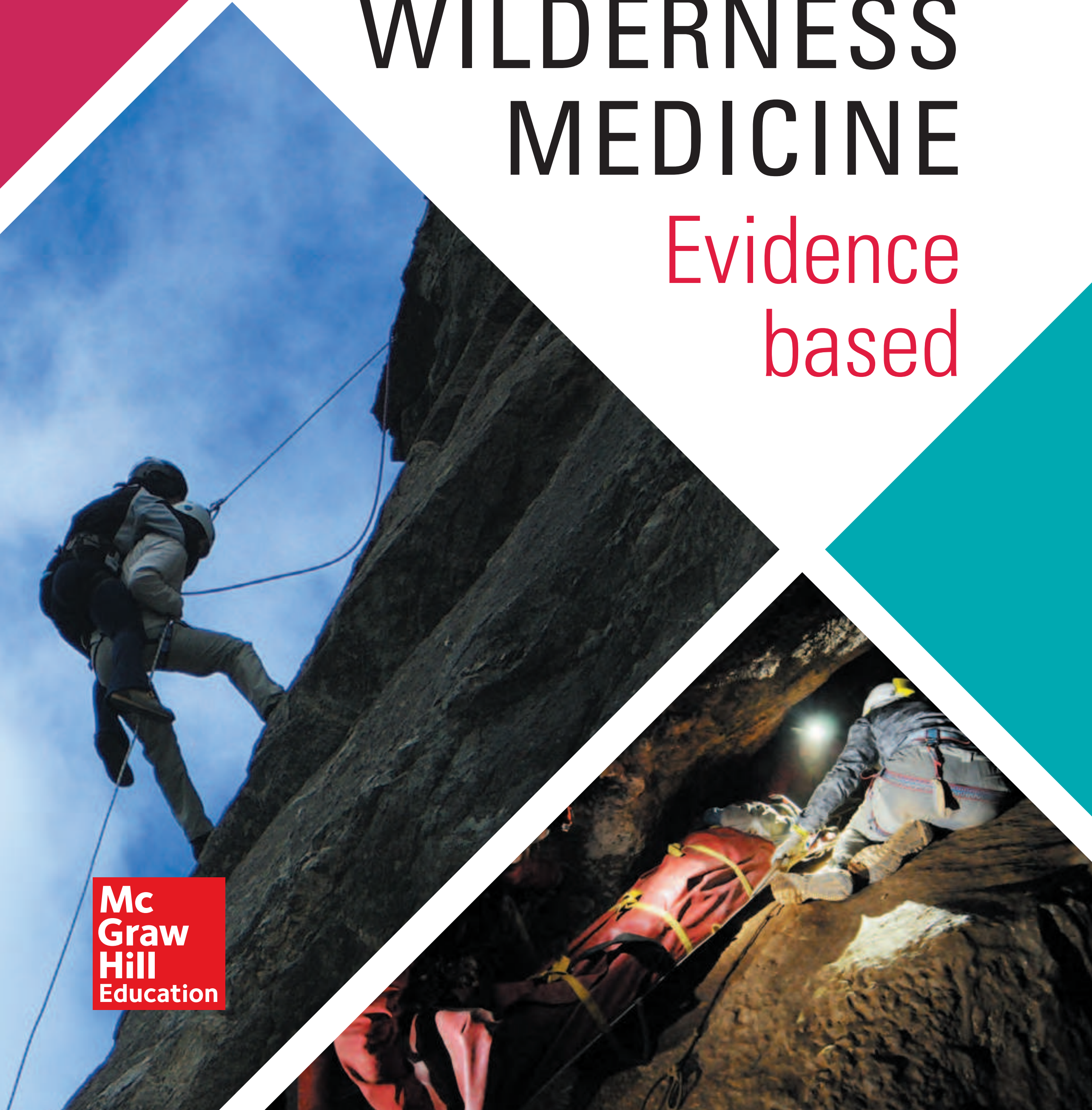
ENRIC SUBIRATS BAYEGO

MOUNTAIN and WILDERNESS MEDICINE

Evidence based



MOUNTAIN AND WILDERNESS MEDICINE

(Evidence-based)

Director Enric Subirats Bayego, M.D.

Mc Graw Hill Education

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For Maria Teresa, David and Gemma.
For my whole family.

CONTENTS

About the author XI
Reviewers and collaborators XIII
Acknowledgements XVII
Foreword by Drs. Oliver Reisten and Giacomo Strapazzon XIX
Foreword by Dr. Ramon Pujol XXI
Preface. How to use this book XXIII

SECTION I. PREVENTION

CHAPTER 1. TRAINING, INFORMATION, EQUIPMENT AND JUDGEMENT

INTRODUCTION 3
SUMMARY OF SOME PRECAUTIONARY MEASURES FOR THE MOUNTAINS 4
INFORMATION OF INTEREST 5
TECHNIQUES AND EQUIPMENT 6
WEATHER ON THE MOUNTAIN 7
QUICK GUIDE TO ORIENTATION FOR THE MOUNTAINEER 11

CHAPTER 2. NUTRITION

WHY DO WE EAT? 15
HOW MUCH ENERGY DO WE NEED? 15
THE ESSENTIAL INGREDIENTS 18
THE BALANCED DIET 28
NUTRITIONAL RECOMMENDATIONS FOR SPORTSPEOPLE 30
RETENTION OF FOOD IN THE STOMACH 33
WATER PURIFICATION 36

CHAPTER 3. PHYSICAL PREPARATION

THE PHYSICAL FORM 39
PHYSICAL EXERCISE AND HEALTH52 39
WHAT LEVEL OF PHYSICAL EXERCISE IS BENEFICIAL TO HEALTH? 39
PHYSICAL EXERCISE AND IMPROVING ATHLETIC PERFORMANCE 42
SPORTS TRAINING 45
BASIC PHYSICAL QUALITIES 45
RISKS OF EXERCISE 51

SECTION II. ENVIRONMENT-RELATED PROBLEMS

CHAPTER 4. TEMPERATURE REGULATION

MECHANISMS OF HEAT LOSS 57
MECHANISMS OF ADAPTATION TO TEMPERATURE CHANGES 59

CHAPTER 5. HYPOTHERMIA

CONCEPT 61
EPIDEMIOLOGY 61
PHYSIOLOGY 61
CLINIAL PRESENTATION 64

COMPLEMENTARY EXPLORATIONS 65
CLASSIFICATION 66
PREVENTION 66
TREATMENT 69
MOST FREQUENT COMPLICATIONS 76
PROGNOSIS 76

CHAPTER 6. FROSTBITE AND OTHER COLD-RELATED ILLNESSES
CONCEPT 77
EPIDEMIOLOGY 77
PATHOPHYSIOLOGY 77
CLINICAL PRESENTATION 78
PREVENTION 80
TREATMENT 81
EVOLUTION 84
OTHER COLD-RELATED CONDITIONS 84

CHAPTER 7. HEAT, DRYNESS AND HUMIDITY
HEAT 87
DRYNESS 92
HIGH HUMIDITY 92

CHAPTER 8. SOLAR RADIATION
SUN AND THE SKIN 93
SUN AND THE EYES 96

CHAPTER 9. FULGURATION
LIGHTNING 99
FULGURATION 99
FOG 102
WIND 103

CHAPTER 10. ALTITUDE
CONDITIONS RELATED TO ALTITUDE 105
DIAGNOSIS 106
TREATMENT 109

CHAPTER 11. ANIMAL BITES AND STINGS
MAMMAL BITES 111
ARTHROPOD BITES 112
SNAKE BITES 119

CHAPTER 12. POISONING BY PLANTS
ACONITUM NAPELLUS (BLUE) AND *ACONITUM VULPARIA* (YELLOW) 123
ATROPA BELLADONA 124
BRYONIA DIOICA 125
COLCHICUM AUTUMNALE 125
CONIUM MACULATUM 126
CORIARIA MYRTIFOLIA 126
DAPHNE MEZEREUM 127
DATURA STRAMONIUM 128
HEDERA HELIX 128
LONICERA XYLOSTEUM 129
NERIUM OLEANDER 129
RICINUS COMMUNIS 130
URTICA URENS AND *URTICA DIOICA* 131

CHAPTER 13. MUSHROOM POISONING
INTRODUCTION 133

CLINICAL PRESENTATION 133
GENERAL MANAGEMENT 135
RECOMMENDATIONS TO PREVENT MUSHROOM POISONING 137
TECHNIQUES USED IN THE TREATMENT OF POISONING 137

SECTION III. PROBLEMS ARISING FROM ACCIDENTS

CHAPTER 14. CARDIOPULMONARY RESUSCITATION

THE CARDIORESPIRATORY SYSTEM 141
LIFE SUPPORT 142
CARDIOPULMONARY RESUSCITATION (CPR) 145

CHAPTER 15. MOUNTAIN FIRST AID AND EMERGENCY PROCEDURES

OVERVIEW 153
MOUNTAIN FIRST AID 154
EMERGENCY PROCEDURES 155
SUMMARY 162

CHAPTER 16. IMMOBILISING AND MOVING THE VICTIM

MOVEMENT METHODS 163
MOVING AND IMMOBILISATION EQUIPMENT 165
EVACUATION 168

CHAPTER 17. ANALGESIA AND SEDATION

TREATMENT OF PAIN 171
ANTIEMETICS 174

CHAPTER 18. HELICOPTER EVACUATION

SAFETY STANDARDS WHEN USING A HELICOPTER 176
PATHOPHYSIOLOGY OF HELICOPTER TRANSPORT 179
ACCELERATION AND DECELERATION 181
VIBRATIONS 182
NOISE 182
TEMPERATURE 182
OTHER FACTORS 182
PREPARATION OF THE PATIENT FOR TRANSPORT 182
HOIST RESCUE OPERATIONS 183
HEMS PROGRAMME ACCIDENT RATE 185

CHAPTER 19. HAEMORRHAGE, SHOCK AND SUSPENSION TRAUMA

HYPOVOLAEMIC SHOCK (HAEMORRHAGIC) 187
NEUROGENIC SHOCK 191
SUSPENSION TRAUMA (HARNESS HANG SYNDROME) 191
OTHER TYPES OF SHOCK 192

CHAPTER 20. CRANIOENCEPHALIC AND SPINAL TRAUMA

THE NERVOUS SYSTEM 193
CRANIOENCEPHALIC TRAUMA 193
SPINAL TRAUMA 198

CHAPTER 21. THORACIC AND ABDOMINAL TRAUMA

THORACIC TRAUMA 203
ABDOMINAL TRAUMA 207

CHAPTER 22. MUSCULOSKELETAL LESIONS

THE MUSCULOSKELETAL SYSTEM 209
PREVENTION OF MUSCULOSKELETAL LESIONS 210
MUSCULOSKELETAL LESIONS: GENERAL 211

DRESSINGS AND IMMOBILISATIONS 216
THE MOST COMMON FRACTURES AND DISLOCATIONS OF EXTREMITIES IN THE MOUNTAINS 218

CHAPTER 23. SOFT TISSUE INJURY

CONTUSIONS OR BRUISES 243
BLISTERS 243
SUBUNGUAL HEMATOMA 243
INGROWN TOENAILS 244
PUNCTURE WOUNDS WITH EMBEDDED OBJECT 244
ABRASIONS, LACERATIONS, AND WOUNDS THAT DO NOT REQUIRE SUTURING 244
TREATMENT OF WOUNDS THAT REQUIRE SUTURING 246
DRESSINGS AND BANDAGES 247

CHAPTER 24. BURNS AND SCALDING INJURIES

BURNS 249
SMOKE INHALATION SYNDROME 251
CARBON MONOXIDE POISONING (CO) 251
DROWNING 252

CHAPTER 25. INJURIES IN CANYONING AND CAVING

EPIDEMIOLOGY 253
CANYON AND CAVE RESCUES 254

CHAPTER 26. AVALANCHES

TYPES OF AVALANCHES 257
FACTORS THAT FAVOUR TRIGGERING OF AVALANCHES 258
RISK ASSESSMENT. THE EUROPEAN AVALANCHE DANGER SCALE 259
SAFETY DEVICES 259
SAFETY TESTS 260
PREVENTION 260
RESCUE 262
IMMEDIATE TREATMENT OF THE VICTIM 264
PROGNOSIS OF PERSONS INJURED IN AN AVALANCHE 265

SECTION IV. ILLNESSES IN THE MOUNTAIN

CHAPTER 27. ILLNESSES IN THE MOUNTAIN

CHEST PAIN 271
ACUTE ABDOMINAL PAIN 273
ANAL PAIN 277
FEVER 277
VOMITING 278
ACUTE INFECTIOUS GASTROENTERITIS 278
RESPIRATORY PATHOLOGY 279
OPHTHALMIC EMERGENCIES 281
DENTAL ABSCESS 282
DISLOCATED JAW 282
OTORHINOLARYNGOLOGICAL EMERGENCIES 282
NEUROLOGICAL PATHOLOGY 284
URINARY PATHOLOGY 287
SKIN INFECTIONS 288
ACUTE LOW BACK PAIN 288
ANAPHYLAXIS 289
RECOMMENDATIONS FOR THE MANAGEMENT OF PRE-EXISTING ILLNESSES OR CONDITIONS IN MOUNTAIN ACTIVITIES 289

CHAPTER 28. CLINICAL TECHNIQUES

OROTRACHEAL INTUBATION 293
LARYNGEAL MASK AIRWAY 296
I-GEL® SUPRAGLOTTIC AIRWAY 297
LARYNGEAL TUBE (KING LT) 297
CRICOTHYROID PUNCTURE 298

CRICOTHYROIDOTOMY 298
CANNULATION OF A PERIPHERAL VENOUS LINE 299
INTRAOSSEOUS INFUSION 300
THORACENTESIS AND THORACIC DRAINAGE 301
THORACIC TUBE 302
URGENT PERICARDIOCENTESIS 303

CHAPTER 29. MEDICAL EQUIPMENT

MOUNTAIN FIRST AID KIT 305
RESCUE BACKPACK 307
BASIC TREATMENT MATERIAL 309
STERILIZATION OF THE EQUIPMENT 309
NORMAL DOSAGES, CONTRAINDICATIONS, PRECAUTIONS AND MOST NOTEWORTHY SIDE EFFECTS OF SOME DRUGS MENTIONED IN THE TEXT 309

BIBLIOGRAPHY 317

GLOSSARY 333

INDEX 341

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Enric Subirats Bayego is a Doctor (MD, PhD), with Honours, of Medicine and Surgery, specialising in Internal Medicine. Currently working as the Medical Director and Head of the Department of Medicine at the International Hospital of Cerdanya (Eastern Pyrenees), he graduated in Public and Community Health from the University of Nancy (France) and in Mountain Emergency Medicine from the University of Toulouse (France). He has published more than 200 articles in his speciality, in both national and international medical journals; has worked as a professor in the universities of Barcelona, Toulouse, Ramon Llull and Pompeu Fabra and is currently Professor of the University of Girona Faculty of Medicine, and Director of the Chair of Mountain and Wilderness Medicine and Clinical Simulation. Enric is medical advisor to the International Union of Alpine Associations (UIAA) on its anti-doping commission, delegate of the International Commission for Alpine Relief (CISA-ICAR) and a member of the scientific committee of the Laboratoire Européen Performance Santé Altitude (LEPSA). He also currently runs the "International Diploma of Mountain Medicine", approved by the medical commissions of the International Climbing and Mountaineering Federation (UIAA), the International Commission for Alpine Rescue (CISA-ICAR) and the International Society of Mountain Medicine (ISMM). He worked as a doctor at the La Molina ski station and in the Helineu air rescue service in the Catalan Pyrenees and is currently the medical manager of the Masella Ski Resort.

Mountain guide, sports coach and instructor of the Catalan School of High Mountains, Enric has collaborated as a teacher in various Technical Mountain Climbing and Winter Sports training schools, and in the courses of the Catalan Association of Ski Resorts and Mountain Activities. He is the author of the manuals "First Aid and Emergency Medicine in the Mountains" and "Prevention and First Aid on the Mountain" and co-author of "Safety and Rescue on the Mountain" and "Treatments, dressings and immobilisations in the mountains".

He likes the pleasant sensation of freedom that he feels when walking, running, climbing or skiing in the mountains, so he practises most mountain activities: hiking, mountaineering, climbing, skiing in its different forms and mountain races, and has competed in mountain marathons (Aneto, Mulleres, etc.) and mountain ski races (Patrouille des Glaciers, etc.). He has carried out mountain trips and activities in the Pyrenees, Alps, Sahara, Hoggar mountains, Lapland, Iceland and Greenland. He thinks that mountain sports help us feel relatively comfortable in the face of life's uncertainties and also put us in our place by healing excess ego. But what he likes most about the mountains is that there is room for everyone, because they are a place where you can have a good time almost every time, and there is always a given type of mountain sport and a certain level of difficulty adapted to each individual and every moment of their personal life.

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FOREWORD BY DR. O. REINSTEIN & DR. G. STRAPAZZON

Dear colleagues and friends:

For many years Dr. Enric Subirats has dedicated himself to mountain related training, research and medical assistance, and during this time he has written books related to different mountain activities and for different audiences, both for healthcare personnel and for mountaineers in general.

This book that you are holding in your hands includes knowledge, from the most basic that any mountaineer should know, up to the deepest aspects of mountain medicine, but explained in a very complete and comprehensible way. It is the first book on wilderness medicine in which the foundations of evidence-based medicine have been used for its development, not the "eminence", which is so difficult to apply in mountain medicine.

Dr. Enric Subirats and his co-authors, in an easy to understand way and based on his extensive experience in the world of rescue, have adapted this book to both beginners in the world of first aid in the mountains, as well as experts in the field of mountain medicine and rescue. They introduce the inexperienced mountaineer to the field of mountain medicine with chapters focusing on prevention, or explaining how environmental factors can influence our body during recreational activities in remote and mountainous areas.

The work pays particular attention to the most common injuries in mountain areas, the traumatic ones; but it also analyses illnesses that can occur there, in accordance with UIAA classification. Each chapter includes pathophysiological bases, diagnosis, treatment and practical advice. The section on the use of basic and advanced techniques in mountain emergencies and urgent situations is especially adapted to the context of pre-hospital care in remote and mountainous areas. A very useful chapter describing specific materials, drug doses and logistical aspects was advised by experts. The book also provides information on specific situations, apart from altitude pathology, such as accidents in avalanches and crevices, accidents in caves and ravines, and specific aspects of aerial rescue.

To conclude, it is a fact that the book that you are about to read is the essence of the work and experience of many years, guided always by scientific evidence, and for this reason we are convinced that it is destined to become a work of reference.

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FOREWORD BY DR. RAMON PUJOL

The fundamental goal for human beings seeking contact with nature is none other than to experience the physical and psychological benefits this refreshing relationship offers us. With the passing of years, western societies have experienced a dramatic increase in activities linked to the enjoyment of the wilderness.

This trend, facilitated by improvements in means of transportation and communication, along with improvements in care of the natural environment, on many occasions is not paralleled by the level of preparation necessary to ensure that the pleasure does not pose a health risk. Mountain sports, which years ago were practised by a minority in general prepared for it, are now within the reach of the majority of citizens who should know better the details of the planned activities and the potential risks, and accept the advice available prior to starting them. In this world the well-known aphorism that “information is power” is really valid, and in this case it is a very practical power.

The generalisation of wilderness activities already has no borders or limits; the existence of chronic diseases, disabilities, extreme ages, or other circumstances that once upon a time were inadvisable, now not only are allowed, they are encouraged. Neither are limits on what a human being is able to do in this environment. Leaving our natural habitat to experience the pleasures linked to the natural environment has become a routine that was not popular in previous generations. Ballooning, climbing to summits that once seemed inaccessible, or solo circumnavigation of the globe on a yacht, have all become news of immediate and universal coverage that transforms its actors into leaders admired by many citizens who wish to imitate them.

In short, the approach of the human towards the natural environment is a very positive one, but must be exercised with a respectful coexistence, and not just at any price.

The appearance of this book provides not only useful knowledge but also, as an added value, a great rigor; the fruit of having passed through the filter of scientific evidence. Without wishing to detract from the value they once had in medicine, the home remedies once provided by grandmothers or locals, to solve health problems that could unexpectedly affect hikers or adventurous travellers, are no longer worthwhile. These days, the best decisions are based on studies that show what is the best way of preventing or resolving diseases that can affect our body in the practice of sports, or when simply resting in the natural environment. Their potential gravity more than justifies its study and dissemination.

I know the author of the book very well. It would be very difficult to find someone who combines the enthusiasm, restlessness and vocational dedication to medicine better than him, far from urban hospitals. Careful reading makes these elements apparent, which can also be gleaned from each of the collaborators in each chapter; it is evident that they were not chosen at random. They are enthusiasts and experts in each subject and, like Dr. Subirats, it is impossible not to follow their advice. The leadership capacity of the author is so strong that it has been able to unite authors from diverse backgrounds, all of them united by their love of the mountains. From those who come from prestigious international centres, to their own children who have caught the bug and follow the saga; all of them put their greatest interest into making reading this book a pleasure only comparable to that of the physical activity that the reader has carried out, or plans to carry out.

The author's desire for self-improvement should also be noted. We find ourselves with the sixth work he has done on the same subject and it must be said that the progress has been very notable in both content and form, the style imbued by his university activity being evident. As a mountain sportsman who constantly sets himself new goals, Enric Subirats has managed to complete another personal challenge that the rest of us thank him for, both as readers and as patients (who we have also been), but above all as the friends of an exceptional person.

Finally, to share the spirit of Enric: 1) working without limits but always enjoying it with contagious joy, 2) passion for sport and nature (and music), 3) authentic companionship, 4) curiosity for acquiring new knowledge, 5) generosity.

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PREFACE. HOW TO USE THIS BOOK

PRESENTATION

Wilderness medicine responds to the need to provide health care to people far removed from health resources and often in a hostile environment. Changes in life style (diabetic hikers, cyclists with coronary stents, etc.) have boosted the interest in this discipline.

The factors that characterise it are:

- Extreme or difficult to control environmental conditions: natural elements (extreme weather) and human factors (remote communities, expeditions, armed conflict zones) can cause a medical problem or destabilise a pre-existing problem.
- Limited resources: the ideal treatment may not be applicable if one takes into account the weight, volume, functionality, and availability of resources. The capacity for improvisation will determine what resources are most functional in a particular set of precise circumstances.
- Delay in evacuation or the arrival of definitive health-care because of distance, logistics, or dangers.[1]

Wilderness medicine encapsulates elements of emergency medicine, internal medicine, family medicine, sports medicine, orthopaedic surgery and traumatology, public health and travel medicine.

At the research level, the effects of the natural environment on health have opened up a wide range of projects: exposure to cold and heat, treatment of injuries from animals and plants, physiology of endurance sports, or the management of medical problems away from healthcare resources or in a hostile environment (diabetes, etc.)

This practical manual of mountain and wilderness medicine is intended for healthcare professionals whose work takes place in the natural environment: medical and health care personnel of ski resorts, mountain rescue groups and health professionals that carry out their activity in rural areas.

Some parts of the book are also useful to mountain first aid professionals (ski patrol and members of rescue groups), mountain professionals who occasionally need to participate in rescue tasks (mountain hut keepers, mountain guides, mountain instructors, ski instructors or outdoor activity monitors), and even to climbers of any level interested in having a reference book to broaden their knowledge of first aid in the mountains.

The changes that this book brings to existing manuals of mountain and wilderness medicine on the market are:

- The updating of topics.
- The methodology used for their preparation conforms to evidence based medicine (EBM) and is inspired by the Haynes 6S pyramid of information.
- The incorporation of some clues that indicate the utility of physical examination, as measured by the Odds Ratios (OR+ and OR -).

The introduction explains the methodology used in the writing of this book and the keys to the interpretation of levels of evidence and the usefulness of the extrapolations.

The first section refers to the main preventative measures to avoid the emergence of problems in the wilderness, with special emphasis on dietary and physical preparation.

The second section discusses the specific conditions related to the wilderness: cold, heat, solar radiation, lightning, altitude, wildlife bites and stings, poisoning by plants and mushrooms, etc.

The third section discusses some of the problems resulting from an accident: life support, initial action in the event of an accident, moving and immobilisation of the injured person, analgesia and sedation, helicopter evacuation, haemorrhage, shock and suspension (harness hang) syndrome, cranioencephalic and vertebral column trauma, thoracic and abdominal trauma, trauma to the extremities, soft tissue injuries, avalanches, canyoning and caving injuries, and burns and scalding injuries.

The fourth section briefly reviews some of the diseases that can occur in the natural environment, focusing on those that are either frequent or serious. Basically, it gives some clues for diagnosis and initial treatment.

The fifth section brings together some of the techniques that can be useful for health professionals and proposes some ideas on the basic equipment to be included in the first-aid kit, the rescue backpack and the basic items for a doctor's office in the wilderness (e.g. a ski slope). It also includes a small handbook with information on the medicines mentioned in the text.

Finally, it adds an updated bibliography, a glossary, and an alphabetical index to facilitate searching.

The book is focused on servicing emergencies in our mountains and does not cover the specific aspects of mountains that are of great altitude, tropical, or exceptionally isolated from health centres, although a great many of the issues exposed can be extrapolated to these situations.

THE METHODOLOGY USED FOR THE DRAFTING OF THIS MANUAL

In writing this book, we have attempted to integrate the best scientific evidence with the authors' clinical experience and the characteristics, expectations and preferences of patients, all of which constitutes evidence-based medicine (EBM).

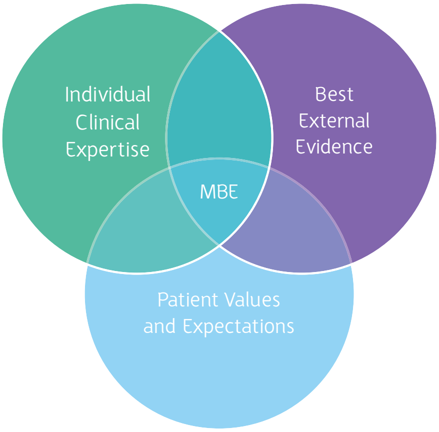
Individual Clinical Expertise
Best External Evidence
MBE
Patient Values and Expectations

Figure 1. The triad of Evidence-Based Medicine (EBM).[2]

The methodological foundation was inspired by the Haynes 6S pyramid of information.[3]

- Firstly, meta-search engines were consulted that offer the information filtered and ordered according to the Haynes pyramid (Trip Medical Database).
- Secondly we consulted book text abstracts using EBM methodology (Clinical Evidence, Uptodate, eMedicine-Medscape, Bandolier, CKS or Clinical Knowledge Summaries, Clinical practice guidelines: National Guideline Clearinghouse, NICE).
- Thirdly we consulted journal abstracts using EBM methodology (ACPJ, EBM).
- Fourth, systematic reviews (Cochrane Collaboration, DARE) and question and answer systems (Q&A: http://www.tripanswers.org).
- In fifth place, original articles (Medline).
- And finally the opinions of experts.

Clinical doubts became structured questions (PICO system), then tests (evidence) were sought to clarify the doubts, the tests were critically evaluated and it is this scientific knowledge that has been integrated with the clinical experience and the specific characteristics of the patients.

The text has been revised by a diverse collective composed of doctors, nursing staff, rescue personnel, mountain professionals and mountaineers who have made extremely enriching modifications.

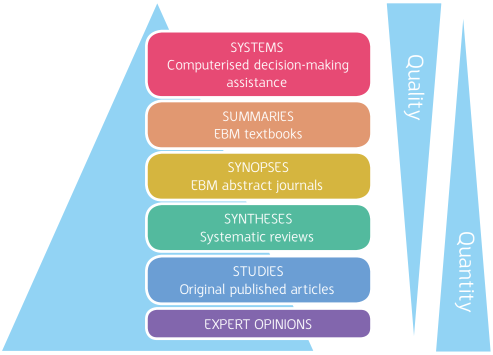

Figure 2. Haynes 6S pyramid of information.[3]

KEYS TO ASSESS THE RELEVANCE OF THE PHYSICAL EXAMINATION

We have used the likelihood ratio to assess the usefulness of the signs and symptoms associated with various pathologies, because of the advantages it offers over other concepts[4]. The table shows the usefulness of these ratios

Table 1. Relationship between the likelihood ratio and the change of diagnostic probability[4]

Odds ratio	Change in the diagnostic probability
0.1	−45%
0.2	−30%
0.3	−25%
0.4	−20%
0.5	−15%
1	Does not vary
2	+15%
3	+20%
4	+25%
5	+30%
6	+35%
7	
8	+40%
9	
10	+45%

Values ≥3 or = ≤0.3 are clinically relevant.

The positive likelihood ratio indicates how much more likely is to find a positive result in ill people compared to healthy people. The negative likelihood ratio is the quotient between the probability of a negative result in ill people and the likelihood of a negative outcome in healthy ones[4]. It guides the proportion in which the probability of suffering or not suffering from a pathology increases or decreases, starting from a determined prevalence.

LEVELS OF EVIDENCE AND GRADES OF RECOMMENDATION

Wherever possible, the degree of recommendation of proposals has been classified according to the level of evidence, following the classification of the US Agency for Health Care Policy and Research. In the text the levels are represented with the letters **(A)**, **(B)** or **(C)**.

Table 2. Levels of evidence and grades of recommendation

Level	Type of scientific evidence (SE)
Ia	The SE comes from a meta-analysis of randomised controlled clinical trials.
Ib	The SE comes from at least one randomised controlled clinical trial.
IIa	The SE comes from at least one well-designed, non-randomised, controlled prospective study.
IIb	The SE comes from at least one well designed quasi-experimental study.
III	The SE comes from non-experimental descriptive studies, well designed as comparative, correlation or case-control studies.
IV	The SE comes from documents or opinions of expert committees and/or clinical experiences of prestigious authorities.
Grade of recommendation	
A	contains SE levels Ia and Ib
B	contains SE levels IIa, IIb and III
C	contains SE level IV

In any case, there is great variability in clinical practice and very few, if any, universal truths. Therefore, the text is open to criticism and contributions that may be made in order to improve a future edition.

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WARNING

We have made every effort to verify the accuracy of the therapeutic doses recommended in this manual. Even so, it is possible that there are inadvertent errors in the transcription of the amounts, units or intervals. Although most of them reflect well-established international guidelines, the indications and dosages of certain drugs, as well as their side effects, contraindications and interactions, may change as knowledge advances.

For this reason it is recommended, when appropriate, to consult more extensive specialised texts, as well as the various publications on the subject.

Section I

PREVENTION

CHAPTER 1
Training, information, equipment and judgement

CHAPTER 2
Nutrition

CHAPTER 3
Physical preparation

1

TRAINING, INFORMATION, EQUIPMENT AND JUDGEMENT

INTRODUCTION

Activities carried out in the wilderness may pose a risk due to their biomechanics, the weather conditions and mountainous terrain where they occur.

Training properly by means of courses, or by hiring a guide, increases safety and helps to prevent accidents.[5, 6] The wilderness offers itineraries of different technical and physical difficulty, and it is advisable to choose the one best adapted to the level of the group. Be humble and realistic when judging your own ability and always remember that the level of a group is that of its weakest member. Guido Lammer, a pioneer of solo climbing, stated that overestimation of one's own ability is the greatest mountain danger (Fig. 1.1).

The best way to minimise problems is to prevent them, but if an accident does occur, you should only do what you know how to do in order not to produce a greater evil *(primum non nocere;* first, do no harm*)*. An unwritten rule in mountain medicine is to do the **minimum necessary.** The primary treatment objectives of the injured person in the wilderness are to save their life, minimise negative effects and soothe pain; postponing non-essential manoeuvres from being performed that may delay the rescue until the injured person has been evacuated to the health centre or to a more comfortable area. Nervousness must also be controlled, as it could lead to an accident in people seeking help, or in those who are going to provide help, and transform the situation into a multiple accident.

Before you do a mountain activity it is imperative to obtain the maximum **information** about the area, route and weather conditions. Problems caused by the bad weather are partly anticipated by consulting weather forecasts, although at best they have an error rate of approximately 14%.[7] It is also recommended to know the avalanche risk. It is important to consult the literature and to seek advice from mountaineers with the most experience or knowledge of the area.

It is advisable to use appropriate **equipment** for the planned activity. Clothing should consist of several layers that maintain body temperature, to eliminate sweat, and protect you from the wind and precipitation, not forgetting hat, gloves and glasses. It is recommended to wear a light hat for protection from the sun or the cold, since approximately 30% of body heat is lost through the head. Sunglasses should pro-

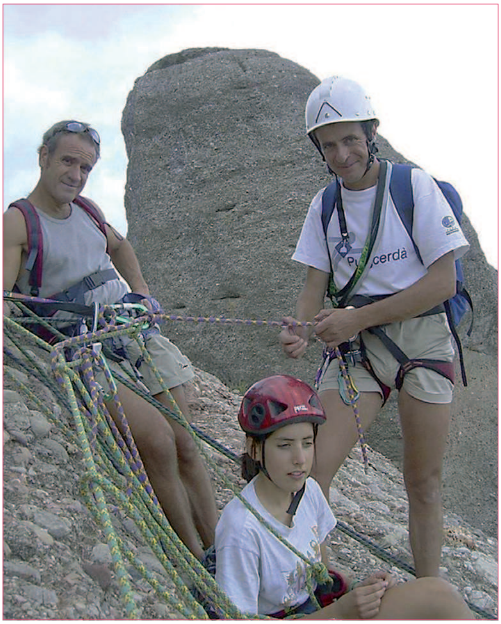


Figure 1.1. Training.

tect you from ultraviolet radiation. The boots should not rub, and the soles should be as slip resistant as possible: there are frequent mountain accidents due to slipping on slopes with snow or long grass. If you use crampons, they must have anti-balling plates, to prevent snow from sticking to the bottom of the crampon.

Specific safety equipment should be taken with you depending on the activity to be performed. Such equipment must be approved and in optimal condition for use; the price of a life is superior to that of a new rope. It is necessary to periodically conduct equipment maintenance and adjustment.

It is prudent to include a small first-aid kit in the equipment and a mobile phone for emergency calls.

Without a correct **diet**, adequate **hydration** and good **physical preparation** you will not get good sporting results for a long time. These sports medicine concepts are equally applicable to non-competitive mountaineering, therefore if you are in in better condition you will enjoy your activity more and, in addition, you will have a reserve of energy that could be useful in the event of difficulties. Regular practising of physical exercise to avoid injury is recommended. The cheapest preventive medicine is probably diet, hydration and physical preparation.

It is advisable to get properly immunised against tetanus, due to the cuts and abrasions that you can suffer.

Despite all of this, a mountaineer can have a great education, be very knowledgeable, have excellent equipment, be well nourished, hydrated, and well-trained, but lack **sense**. Do not hesitate to withdraw from the chosen objective if the conditions are not favourable; it is considered that the goal is only achieved in 40% of cases, even when working at full performance. As Whymper said: “Climb if you will, but remember that courage and strength are nought without prudence, and that a momentary negligence may destroy the happiness of a lifetime”.

In general, from the psychological point of view, people who practice mountain sports are mentally balanced[8] and in comparison with other athletes, or the sedentary population, share the following characteristics: extroversion, emotional stability, low impulsivity, low level of anxiety and seek experiences.[9]

Figure 1.3. Rock climbing 1.

SUMMARY OF SOME PRECAUTIONARY MEASURES FOR THE MOUNTAINS

Table 1.1. Preventative activities in the mountains

Preventative activity	Benefits
Training	By knowing the risks and protective measures, more resources are available to address them
Balanced diet	Improves physical state and performance
Physical preparation	Improves physical state and performance
Adequate hydration	Improves physical state and performance
Appropriate rest	Improves physical state and performance
Appropriate clothing	Improves body temperature regulation, avoiding illness caused by cold or heat

Table 1.1. Preventative activities in the mountains (Cont.)

Boots with non-slip soles and crampons with anti-balling plates	Reduces the risk of slipping (primary cause of mountain accidents)
Technical Material in optimal condition for use	Reduces the risk of an accident
Sunscreen SPF 15 or higher	Prevents skin lesions produced by the sun
Sunglasses with protection level 3 or 4	Prevents ocular lesions produced by the sun
AVD, shovel and probe	Increases the chance of survival after being buried by an avalanche
Airbag, Avalung	Increases the chance of survival after being buried by an avalanche
Helmet	Reduces the severity of cranioencephalic trauma in mountain biking (MTB), sport and classic climbing, skiing and other mountain activities
Wrist protectors	Reduces the chance of wrist fracture in snowboarding
Adjustment of ski bindings	Reduces knee injuries
Telescopic trekking poles	Reduces the load on knees and spine
Backpack with well adjusted waist strap	Reduces the load on shoulders and back

INFORMATION OF INTEREST

Mountain accidents; European emergency telephone number: **112.**

Table 1.2. Web pages of interest

Weather and avalanches (see also “Weather”)	
Spain	http://www.inm.es/ <Broken link>
Catalonia	http://www.meteocat.cat <Broken link>
Germany	http://www.dwd.de/de/de.htm. <Broken link>
Austria	http://www.zamg. ac.at/
Finland	http://www.fmi.fi/
France (in French)	http://www.meteofrance.com/FR/index.jsp
Great Britain	http://www.met-office.gov.uk/
Iceland	http://www.vedur.is/
Italy	http://meteo.cineca.it/
Switzerland	http://www.meteoschweiz.ch/web/de/wetter.html
Sweden	http://www.smhi.se/
Association for Snow and Avalanche Awareness. (in Catalan and Spanish)	http://www.acna.cat
National Association for the Study of Snow and Avalanches (in French)	http://www.anena.org/index.html
Weather in ski resorts	http://www.snow-forecast.com/
State of frozen waterfalls (In French)	http://www.ice-dreams.com/ <Incorrect link?>
State of frozen waterfalls (In French)	http://www.ice-fall.com/
Avalanche team of the University of Barcelona (in Catalan)	http://www.ub.es/allaus/
Cartographic institute of Catalonia. Snow and avalanche area	http://www.icgc.cat/
Sport institutions	
Spanish Federation of Mountaineering and Climbing (in Spanish)	http://www.fedme.es/
Catalan Federation of Mountaineering and Climbing	https://www.feec.cat/
French Federation of Mountaineering and Climbing (in French)	http://www.ffme.fr/index.php
International Climbing and Mountaineering Federation (UIAA)	https://www.theuiaa.org/
Medicine and rescue	
Association for research, training and health care in the wilderness (in Spanish)	http://www.mountain-medicine.org

Table 1.2. Web pages of interest (Cont.)

Medicine and rescue	
Chair of Mountain and Wilderness Medicine and Clinical Simulation at the University of Girona (in Catalan)	http://www.udg.edu/catedramedicinamuntanya
Association Médecins de Montagne (in French)	http://www.mdem.org/
EURAC Institute of Emergency Mountain Medicine	http://www.eurac.edu/en/research/health/moumed/Pages/default.aspx
'Alpine Rescue Center' by Air Zermatt	https://atc.air-zermatt.ch/wordpress/en/
European Laboratory for Altitude Health Performance (in French)	http://lepsa.univ-perp.fr
Polish Rescue Training Institute (GOPR - in Polish)	http://www.gopr.pl
Catalan Association of Ski Resorts and Mountain Activities (in Catalan and Spanish)	http://www.catneu.cat
Mountain Medicine Training and Research Institute (in French)	http://www.ifremmont.fr/
International Society of Mountain Medicine	http://www.ismmed.org/
Wilderness Medical Society	http://wms.org/
Spanish Society of Mountain Medicine and Assistance (in Spanish)	http://www.semamweb.com/
International Society for Skiing Safety	http://www.isssweb.com/
International Commission for Alpine Assistance	http://www.ikar-cisa.org/
Medical service of the Chamonix National School of Skiing and Mountaineering (ENSA)	http://www.ensa.sports.gouv.fr/
Mountain Rescue Association	http://www.mra.org/
National Ski Patrol USA	http://www.nsp.org
Search and Rescue Society of British Columbia	http://www.sarbc.org/index-n.html
Association of ski resort safety units	https://www.pisteur-secouriste.com/
National Mountain Safety Observation System	http://www.ensa.sports.gouv.fr/
Mountain Documentation and Information Centre	http://sgim.drac.com/

TECHNIQUES AND EQUIPMENT

What physical and technical level should a doctor or health worker have to participate in a rescue? What equipment should I take?

These questions have been asked more than once by both health workers and rescuers. By health workers because they know that sometimes they must work in adverse conditions and difficult to access places. By rescuers because they don't want to have to be keeping an eye out for the health workers while performing the rescue. It is important that the health worker is self-sufficient and only needs the rescuer's help at specific moments. Likewise, the rescuer will carry out their task with greater speed and peace of mind knowing that the health worker is able to look after themselves. Ideally, health workers should have a broad background as mountaineers, climbers and skiers, or be mountain guides. As this is unlikely, this section sets out the minimum technical and physical knowledge and skills that are considered necessary for a health worker to participate safely in a wilderness rescue, although they will not be alone in these operations and will have the help of rescuers.

Table 1.3. Minimum technical and physical condition necessary for participating as a health worker in a wilderness rescue

Stamina: ability to climb 800 m of slope in less than 2 hours on foot, with mountain skis or snowshoes.
Rock climbing: being able to climb as a second in a rope team, scaling rock sections of up to 4 degrees of difficulty. Must not have a fear of open spaces or vertigo.
Climbing in snow or ice: ability to climb as a second in a rope team with crampons and ice axes on sections with up to 60 degrees of inclination. Be confident in using an ice axe and crampons on sections with up to 40 degrees of inclination.

Table 1.3. Minimum technical and physical condition necessary for participating as a health worker in a wilderness rescue (Cont.)

Know the techniques of descent (abseiling) with one or two ropes in a confident, fluid and self-assured manner.
Know the techniques for ascending a rope in an confident and fluid way. (Hand and Croll and hand and Gri-Gri).
Know how to progress along a lifeline by passing intermediate anchors with an energy absorbing or dissipating lanyard.
Know how to tie a figure-of-eight knot.
Know how to tie oneself to a belay station with a figure-of-eight knot.
Know the Klemheist (Machard) knot to secure yourself when abseiling.
Know how to swim confidently and smoothly.
Have an intermediate ability level in downhill skiing.
Be familiar with ski techniques in the mountains.
Have completed a helicopter course on access and descent in hovering flight with the winch.
Habitually practice mountaineering.

Table 1.4. Minimum equipment that a rescuer must have for performing a wilderness rescue

• Light hiking mountain boots (trekking type) • High-altitude boots suitable for crampons • Mountain ski boots • Climbing shoes
• Thick, multi-purpose mountain trousers • Thin, multi-purpose mountain trousers • Waterproof and breathable trousers (Gore-Tex or other type) • Technical Windstopper jersey • Technical Windstopper jacket • Feather or PrimaLoft® fibre jacket • Waterproof and breathable jacket (Gore-Tex type) • Technical socks and shirts suited to the season • sHats, gloves, and protective eyewear suited to the activity and the season
• Helmet • Harness • Energy absorbing lanyard • Ascender and foot-loop • Croll and adjusting strap • Grigri and locking carabiner • Reversible rappelling and securing device, or similar • 4 locking carabiners • Rope for Klemheist knot • 120 cm sling
Crampons
Shared equipment to know and use is: ice axe, snowshoes, skis, telescopic poles and a wetsuit for canyoning.

WEATHER ON THE MOUNTAIN

Weather forecast reliability will never achieve 100%. General 24 hour forecasts have a reliability ranging between 85% and 95% and are more reliable in winter and summer, though less so in autumn and spring. Improvement in forecasting is evident, with a current five-day forecast as reliable as a 24 hour one from 1982.

The forecasts in general cannot be extrapolated into mountainous areas. The mountainous zones are complex, with a large number of different heights, slopes, orientations, etc. Therefore the interaction between general and local forecasting is constant. Weather models or maps currently offer great improvements in local forecasting, improving predictive accuracy.

Storms

Storms are one of the most important determining factors in many areas of the planet. The heavy rains that usually accompany them, the violent winds that can accompany some storm systems, plus the electrical activity, all serve to make them queens of meteorological spectacle in the areas where they occur and mountainous areas are very favourable territory for their presence. On Earth, at any given time, between 1,800 and 2,000 thunderstorms are occurring simultaneously and around 100 lightning strikes hit the planet every second!

A storm is a cloudy structure, usually cumulonimbus, which produces intense rainfall, starting and ending abruptly, accompanied by lightning and thunder. If there is no electrical activity to speak of, it is called a downpour and not a storm. The storm cloud par excellence, the cumulonimbus, extends vertically from a few hundred metres above the surface, up to 11 to 13 kilometres (36,000 ft to 43,000 ft) in altitude in the case of the most fully developed clouds.

Storms can be individual; in other words they are a single storm-cell, or they can come in families; that is to say, multicellular storms. In this case it is the sum of the individual cells located next to each other. There is a third type, called supercells: they are the most powerful, biggest and long-lasting.

How do storms form?

Not all storms have the same origin. There are no storms in the colder areas of the planet. In the mid-latitudes they are distinguishable according to their origin:

- Isolated thunderstorm.
- Frontal storms.
- Line squalls.
- Cold drop storm.

Isolated thunderstorm

Occur at mid-latitudes during the warm months of the year; generally from April to September, particularly between June and August.

They usually occur over land, either the mainland, or the interior of islands. Rare at dawn and in the morning, they are most frequent in the early and late afternoon/evening. The great mountain ranges and mountains are their preferred habitat.

They often have a small horizontal footprint, from a few kilometres (miles) to a few tens of kilometres (tens of miles). When associated with large mountain ranges, they tend to be more massive and can even form large towers without exceeding a kilometre (1,100 yds) in horizontal extent. Despite being isolated and with a small footprint, they can be equally violent and contain sleet or even hail. They also tend to be quite static. Despite the fact that the forecasts indicate the possibility of their formation, it is very difficult to pin down exactly where they will occur.

Frontal storms

Are linked to cold fronts. A front of this type is a line that approaches us. We will previously have had higher temperatures. When the front crosses over us, it will produce showers and storms and an abrupt drop in temperature. The winds will suddenly change direction. It can occur at any time of the year, although they are less frequent in winter. The warming during the central hours of the day can feed their intensity.

Their connection to the fronts makes them also have an elongated shape. Their movement is predictable thanks to the weather maps that depict the advance of the fronts.

Squall line

They appear very similar to the above due to their elongated, banded form. They are not the cold front, but they can share its presence. First will come the squall line and after that, the cold front; usually of short duration, but particularly severe, accompanied by strong gusts of wind, heavy rain, hail and plenty of lightning. Anticipating their formation is not easy; however, once formed, it is easier to forecast their direction of advance. They require the utmost caution when in the mountains.

Cold drop storm

Are close to the nuclei of the depressions, near the centre. They do not share a presence with cold fronts. On weather maps, they are identified as “D”, in Spanish. They are also found in the so-called “cold drops”, which are the depressions that are isolated from the “cold front highway” associated with the Jet Stream, located at 50 degrees of latitude in both hemispheres. They grow randomly around the colder areas close to the core of the depression. In general, they move very little. They have very important pluviometric repercussions in the Mediterranean area, being the storms responsible for rainfall of over 800 mm in less than 24 hours in the Alicante area (Jávea 870 mm), in the east of Spain. They tend to form at the end of summer and during autumn.

Phases of a storm: what is its duration?

The storm forms in three distinct phases:

First phase (cumulus or developing stage): they produce intense updraughts assisted by fronts, high temperatures or depressions that lift the air currents, the mountains acting as levers and springboards. The clouds that appear are in the form of fluffy cotton balls that grow, ending up with relatively vertical growth and taking on the aspect of a giant cauliflower. They are called towering cumulus *(Cumulus congestus)* clouds and will result in Cumulonimbus.

Second, or mature stage: the storm is already active and there are strong gusts of rising and descending internal wind, causing severe turbulence. They produce heavy showers, sometimes with hail.

Third, dissipation stage: the storm is over. Only generate descending air currents that tend to completely dissipating the cumulonimbus thundercloud.

The duration of the process can vary a lot. In general between 30 and 120 minutes, although in some cases it may be longer.

Rainfall with no storm

Downpours or heavy rain may fall without any storm, i.e. without thunder and lightning.

Then, the clouds that accompany it will not have a large vertical dimension, but rather, a horizontal one. They will not be cumulonimbus, instead they will be *altostratus* or *nimbostratus*.

Low cloud may cover the high and medium altitude mountain areas, causing very low visibility.

Before and after the rains there can be important winds associated with the fronts and storms that accompany them.

Winds

Where does the wind come from?

The reason for anticyclones, storms, warm and cold fronts, the winds from the valley or the mountain, or the flow of the winds in one direction or another can be explained with a domestic example. This example allows us to understand the reason behind a large part of the atmospheric machinery air situated between ground level and the first 18 kilometres, called the Troposphere. All of the weather phenomena develop in its interior including, needless to say, from 0 to 9,000 metres (0 to 29,500 ft), which are the levels at which mountains are found.

Let's imagine that we are in the shower and that the shower has a curtain to prevent the water flowing out of the shower basin. Suppose that the bathroom is completely closed, with no open doors or windows and no other person inside. When taking the shower with hot water, have we not noticed more than once that the shower curtain repeatedly billows up to almost stick to our body? So there's the explanation for planetary atmospheric circulation!

While we take the shower with hot water, the heat of the jet is diffused into the surrounding air. Remember that warm air, as in a hot air balloon, is lighter than cold and tends to rise. That is, the air around our body and in the interior of the tub, between the curtain and the wall, tends to rise and leave this area creating an area with a "lack of air". This generates a low pressure or squall zone, where the air weighs little. When it circulates up near the ceiling and leaves the cubicle, above the shower curtain, it quickly cools down. The cooler air, heavier than the warm, drops down to the floor outside the cubicle as, "spare air". Here a high pressure area, or anticyclone, is generated. The air then tends to flow from where there is an excess of air, towards a lack of air; from the high to the low pressure. The shower curtain is thus driven towards the interior of the cubicle, sticking to our body. This circulation is due to the differences in heating between different areas of the bathroom. It is the same for the planet. Not all land regions or seas are heated by the same amount and the result ends up being a difference of temperature that sets in motion the anticyclones, storms, various fronts, general winds, and also those of a local nature, such as breezes or valley and mountain winds.

Characteristics of the wind

The wind near the ground is different to the wind at altitude. Below 1,000 meters (1,100 ft), the influence of the soil is the determining factor. Above, the wind flows in a more laminar and predictable way. In spite of this, it will depend on the height of the relief; in the Sierra Nevada it will be laminar, but in the Pyrenees, the freer wind will blow at over 2,000 or 3,000 metres

(2,200 ft to 3,300 ft). It is also influenced by the time of day. At night, near the ground, the wind tends to be lower and by day it tends to be more notable. The cold air is stiller at night, it is more dense and heavy. Above, the wind flows over this cold and nearly immovable air. By day the air is more turbulent, more "playful". With more heat, especially in summer, the warm air tends to rise and becomes less dense. The air and its movements, being a fluid, behave like water. A wind zone becalmed and with difficulty moving is like the water of a lake or swamp, quiet and stagnant. The air currents are like rivers of water. River waters are moved to greater or lesser speeds and are deflected, accelerated or slowed by obstacles. They may even flow in the opposite direction because of the arrangement of the rocks in a river. If we put ourselves on the bank of a wide stretch of river, the waters flow slowly. However, when channelled in a tighter, more narrow section, the water accelerates; these are the rapids. At these points, if you notice the quick and violent flow of the water in the central area, you will notice that, behind the shelter of a rock, the water moves slowly and even flows in a curve, to move almost in the opposite direction.

The air, as a fluid, also exhibits this behaviour. It can surprise us as, in an area lashed by strong winds, we find areas located a very short distance away where the wind doesn't blow, or even moves in the opposite direction. Like the waters of a river.

The great mountain ranges are obstacles of the first order to these "rivers" of air taking into account that the airflow, the winds, blow between the surface and approximately 12 km altitude (39,000 ft); in the mid-latitudes, an obstacle like the Alps, at more than 4 km (13,100 ft) in height, the Pyrenees at more than 3 km (9,800 ft), or the Cantabrian mountains at more than 2 km (6,500 ft), are major obstacles that divert and alter the speed of the winds in a meaningful way.

When a wind hits a mountain range (the windward side) it is forced up and passes over to the other (leeward) side, which is sheltered from the wind, at a different speed. It can often be accelerated as it descends the leeward slope. It is also very common for the wind to suffer ripples and eddies on this side, which is opposite the oncoming wind. These very violent eddies are called rotors. They are the mountain waves.

Almost always, these mountain waves are visible thanks to the formation of spectacular lenticular clouds, that is to say, with the shape of a lens, or of a flying saucer. The famous Föhn wind that blows north of the Alps from the south and strikes Bavaria forms photogenic wave clouds that betray these rotors. In the Pyrenees, in the Cantabrian mountain range, the most frequent northern winds create this type of cloud to the south of the mountains with the formation of spectacular clouds. The Tramontana wind from the north-east of Catalonia, the Mistral in the south-east of France, or the Rhône valley, form clouds of this type further to the south.

What clouds are synonymous with wind?

The clouds that give away the presence of appreciable winds are the *altocumulus lenticularis;* they are lens, lentil, or flying saucer shaped clouds that are generally formed downwind in the lee of a mountain range when the winds strike it and pass over it denoting the presence of strong winds, with marked standing waves. The winds usually blow on the surface as well, though not always.

The Jet Stream is revealed when there are bands of *cirrus, cirrostratus* and *cirrocumulus*. They are the thin, whitish clouds, like a light veil of hair. Cirrostratus form an extensive layer and cirrocumulus have the appearance of a sky full of small grains of gravel.

Altocumulus, which are not lenticular, can also be arranged as parallel bands, as parallel strips or as sheets.

They also denote the presence of strong winds at high altitude and, in this case, are situated at the lower limit of the jet stream.

Low visibility

Fogs: when, where and why?

Let's explain their formation. Imagine a freezer located in a petrol station or supermarket where they sell bags of ice or other frozen products. When you open the door, the outer air immediately comes into contact with the cold air inside, cooling suddenly. The cold air, due to its own physical characteristics, may not contain too much water vapour and it will soon reach saturation, i.e. 100% humidity. At this moment, the gaseous state water vapour will saturate as it cannot exceed 100% and it will become liquid droplets, forming a surrounding cloud. It is exactly the same as happens with the fog that becomes visible during cold days, when we exhale through the mouth. Gas is always breathed in, but when it comes out and finds cold air, that air cannot contain more humidity, or water vapour, and it becomes saturated at 100%; humidity, hence microscopic droplets are formed, which together make a visible "cloud" that emerges from the mouth.

Types of fog

There are four basic types of fog: frontal, radiation, advection and evaporation.

Frontal fog

The clouds of a cold or warm front are "squeezed" by the topography, much like advection, that will soon be addressed. You must exercise extreme caution because of its sudden arrival.

Radiation fog

This the fog that forms on land when it cools down during the longer nights. The radiated heat loss from the soil causes cooling in the air mass closest to the ground. This is the typical winter river valley fog and in the Spanish interior, and in some mountain valleys. It forms blankets of mist that cling to the lower levels, up to about 300 to 500 metres in thickness and, although it dissipates in autumn and spring, in winter this is not always the case.

Advection fog

Almost always occurs in coastal areas and therefore only compromises topographies very close to those zones. The principle of formation is related to the cold seawater above which is situated a mass of warmer air. The cold sea water acts like the inland soil that cools the air in contact with it. Moisture in warm air tends to condense in the cold zone flush with a cold surface, in this case liquid, and the fog or low cloud forms on the surface. Unlike radiation fog, advection fog moves. Typical are the intermittent fog banks that are visible above the sea or ocean and occasionally cross the coast to dissipate some hundreds of metres inland.

Evaporation fog or steam fog

This does not have any great significance in mountain areas. On a lake or swamp with water warmer than the surrounding air, or on the surface of a forest or a warm road, compared to the surrounding air, the air of the lake, swamp, or asphalt will tend to evaporate and cool down. This cooling causes it to form mist in the form of 'steam' that rises from these surfaces. It is not thick or persistent and, therefore, is less likely to endanger our mountain activities.

The difference between fog, mist, sea fog/lake effect fog and haze

Fog is considered to be a reduction in visibility of less than 1 km due to wet particles in suspension with humidity greater than 80%.

Mist is the same physical phenomenon but with a greater horizontal visibility of between 1 and 10km; sea fog is the term that also describes mist, however it is primarily used in marine and coastal areas.

Haze has the appearance of mist, but with dry particles in suspension, humidity below 80%, and a reduction in visibility of between 1 and 10 km.

Fronts are synonymous with mist at medium and, especially, high levels, particularly during the most active part of their passage.

The forecasting of fog is always is general, since the orientation of the different slopes and ridges produces extremely varied local situations.

QUICK GUIDE TO ORIENTATION FOR THE MOUNTAINEER

- Under normal conditions, for every 100 meters that dry air rises, the thermometer will fall by one degree. If the air contains humidity, that will be about 0.5 degrees per 100m.

- The 0° isotherm, or “freezing level”, does not always mean frozen snow from a given altitude on a slope. It is a value indicative of the air mass surrounding us that only represents the height of snow on many occasions.
- The announcement of a warm front may result in light, persistent and steady rainfall, with rising temperatures after its arrival and the possibility of a second front, which will be cold.
- The announcement of a cold front means more intense precipitation, but more sudden and more irregular. There is high possibility of frontal storms between May and September, approximately. The arrival and departure of bad weather is rapid.
- A slowly falling barometer indicates the approach of persistent bad weather. A quick fall indicates bad and sometimes violent weather, but passing rapidly and without being persistent.
- Valley fog in the morning is synonymous with morning stability on the mountain. However, it is never certain to last throughout the afternoon. The rapid mid-morning onset of small “puffy, fluffy, cotton-like” cumulus clouds indicates possible storms in the afternoon during a summer’s day.
- Mountain winds can be very variable and change in terms of direction and speed. In some areas they are is almost impossible to predict. Therefore, forecasts indicate winds at 1,500 m (5000 ft), 3,000 m (10,000 ft), etc. are general and illustrative.
- With constant moderate gales of 50 to 60 km/h (30 to 40 mph), you must rethink your mountain ascent, especially in winter. At high levels, it will be possible for winds to exceed 100 km/h (60 mph) and, therefore, the probability of suffering frostbite is high. In addition, with snow on the ground, visibility can be reduced to zero.
- During a high mountain summer storm, abandon the ridges and peaks. Rocky mountains have frequent lighting strikes. However, without rocks, impacts are significantly reduced. Lightning should never be underestimated. We’re more likely to be struck by lightning than win first prize in the lottery.
- In case of lightning, move away from isolated trees. If you suddenly feel a buzzing sound and your hair stands on end, immediately lie prone on the ground and try to get rid of any metallic items you may have on you, as the risk of a very close lightning strike is very high and imminent.
- According to the State Meteorological Agency, on average there are more than 25 stormy days in the Pyrenees per year and, in some sectors of Huesca and Lleida, the number is close to 30; in the heart of the Iberian System, close to 25; approaching 20 in the Cantabrian Mountains; more than 15 in the Central System; from 10 to 15 in Sierra Morena and the Central, with between 5 and 10 in the Baetic System.
- According to the State Meteorological Agency, the number of annual average days of snow in the Central Pyrenees rises to more than 70. In the rest of the Pyrenees and the Picos de Europa there are over 40; around 15 in Izaña, 25 in the Iberian System, more than 30 in reduced areas of the Central and also in the Sierra Nevada, where it exceeded 35.

Table 1.5. Climatic values in some mountain areas

	Izaña, Tenerife (2,367 m/ 7,767 ft)	Molina de Aragón, Sistema Ibérico (1,063 m/ 3,488 ft)	Navacerrada (1,890 m/ 6,201 ft)	Cerler (1,540 m/ 5,052 ft)	La Molina (1,712 m/ 5,617 ft)
Average annual rainfall	440 L/m^2 (97.19 gal/ sq. yd)	500 L/m^2 (110.44 gal/ sq. yd)	1,326 L/m^2 (292.89 gal/ sq. yd)	1,458 L/m^2 (332.05 gal/ sq. yd)	1,150 L/m^2 (254.01 gal/ sq. yd)
Absolute minimums	−10 °C (14 °F)	−24 °C (−11.2 °F)	−20 °C (−4 °F)		−20 °C (−4 °F)

Table 1.5. Climatic values in some mountain areas (Cont.)

	Izaña, Tenerife (2,367 m/ 7,767 ft)	Molina de Aragón, Sistema Ibérico (1,063 m/ 3,488 ft)	Navacerrada (1,890 m/ 6,20 1ft)	Cerler (1,540 m/ 5,052 ft)	La Molina (1,712 m/ 5,617 ft)
Absolute maximums	30°C (86 °F)	38°C (100.4 °F)	32°C (89.6 °F)		31°C (87.8 °F)
Average annual temperature	2°C (35.6 °F)	10°C (50 °F)	6°C (42.8 °F)	6°C (42.8 °F)	6°C (42.8 °F)
Annual average hours of sunshine	3,433	3,433	2,238		2,248
Average number of days of frost	60	60	142		48
Average number of stormy days	3	3	22		7
Average number of days with fog	73	73	43		36
Average number of days with snow	11	11		42	74
Maximum recorded winds gust speeds	216 km/h (134 mph)	216 km/h (134 mph)	152 km/h (94 mph)		137 km/h (85 mph)

Table 1.6. Internet guides

Global maps	http://www.wetterzentrale.de/pics/avnpanel1.html (**general surface** situation) http://www.wetterzentrale.de/pics/avnpanel2.html (temperatures at 1,500m, 5000ft) http://www.wetterzentrale.de/pics/avnpanel4.html (rain forecast)
Mountain area forecasts	http://www.aemet.es/es/eltiempo/prediccion/montana (text forecast, and nivology) https://www.aemet.es/es/eltiempo/prediccion/modelosnumericos/harmonie_arome http://www.meteo.cat/prediccio/pirineu http://www.igc.cat/web/ca/allaus_butlleti.php (Catalan Pyrenees nivology) http://www.meteofrance.com/previsions-meteo-montagne/#montagne (forecast and nivology)
Data observatories in real time (maximum 1-hour delay)	http://www.aemet.es/es/eltiempo/observacion/ultimosdatos (all of Spain) http://meteomuntanya.cat/ (Catalonia)

2 NUTRITION

WHY DO WE EAT?

Food meets a twofold need.[10-13]

- To produce the energy necessary for the maintenance of life and muscular activity.

  This energy is usually measured in calories (1 calorie = 4,187 joules). A calorie is the heat required to raise the temperature of one gram of water from 14.5 °C to 15.5 °C. The kilocalorie ('large calorie', kcal or Cal) is normally used and it is equivalent to 1,000 calories.

  Our energy comes from the oxidation of the basic nutrient content in foods:

  — Glucosides or carbohydrates.

  — Lipids, or fats.

  — Proteins.

  Glucosides and proteins produce 4 usable kcal per gram and fats 9 kcal per gram.
- To provide the necessary physical substances from proteins, vitamins, minerals and water, to build, protect and repair the different tissues that make up the body.

HOW MUCH ENERGY DO WE NEED?

The body must produce enough energy to cover:

1. **The indispensable baseline necessities for the maintenance of life at rest.** These needs are lower in women and in those older than 45 years of age: approximately 24 kcal/kg/day.

   The Harris-Benedict equation, by including an activity factor, not only estimates useful baseline metabolism, but is also useful in estimating recommended daily calorific intake:

   - Women: [655 + (9.6 × weight in kilos) + + (1.8 × height in cm) – (4.7 × age in years)] × activity factor.
   - Men: [66 + (13.7 × weight in kilos) + (5 × × height in cm) – (6.8 × age in years)] × × activity factor.

   The activity factor is:

   - Sedentary (little or no exercise): 1.2.
   - Slightly active (light exercise, sports 1-3 times per week): 1.375.
   - Moderately active (moderate exercise, sports 3-5 times per week): 1.55.
   - Very active (intense exercise, sports 6-7 days per week): 1.725.
   - Hyperactive (very intense exercises, physical work, 2 hours or more of sport daily): 1.9.

   The calculation of energy expenditure using a gas stress test or accelerometer is more accurate.
2. **Thermoregulation requirements.**

   The extreme mountain environment has been defined by heat (temperature >30 °C/86 °F), cold (temperature <0 °C/32 °F) and altitude (>3,050 m/10,000 ft). A common feature of the three situations is the increase in energy requirements.[14, 15]

   - Cold: the energy requirement increases by 5% when the temperature decreases 10 °C, compared to the average considered normal.
   - Heat: in hot environments the energy consumption increases due to the additional work of ventilation and increased sweat gland activity. Between 26 °C and 30 °C, the increase in energy consumption over 24 hours is estimated to be 4.8%. The increase of energy consumption at 38 °C is 10% compared to the same work carried out at 30 °C.

   Altitude: at altitudes above 4,300 m (14,100 ft) the required baseline energy increases by approximately 5%.

3. **The needs for growth.** Calorie needs are estimated to be 50% higher in adolescents than in adults.
4. **Specific dynamic action.** Calories for energy needs are provided by carbohydrates, proteins and lipids, but burning these substances requires an energy supplement. This energy expenditure depends on each food and is its specific dynamic action. An estimated 3% of the daily food ration is needed to meet these requirements.
5. **The needs for work.** Only 25% of the energy supplied to the body is converted into work, the rest is used for heating, which means that only one in four calories is used for work. These needs represent an approximate minimum of 1,000-1,500 kcal/day.

Table 2.1. Calorie intake depending on activity

Physical activity	Calorific consumption		Intensity
	kcal/kg/min	kcal/h	MET (metabolic equivalent)
Sleeping	0.017	73	1.0
Reading	0.021	89	1.2
Sitting	0.022	92	1.2
Speaking	0.025	104	1.4
Standing	0.025	106	1.4
Writing	0.027	113	1.5
Sweeping	0.031	130	1.8
Typing	0.037	155	2.1
Washing dishes	0.037	155	2.1
Driving a car	0.042	174	2.4
Showering	0.047	199	2.7
Getting dressed	0.049	207	2.8
Washing yourself	0.050	210	2.9
Riding a motorcycle	0.051	213	2.9
Doing DIY	0.054	228	3.1
Washing clothes	0.057	240	3.3
Mopping the floor	0.061	256	3.5
Ironing	0.062	258	3.5
Vacuuming	0.067	281	3.8
Recreational gardening	0.067	282	3.8
Cycling (14 km/h : 8.7mph)	0.100	420	5.7
Descending stairs	0.101	425	5.8
Climbing stairs	0.227	953	13.0
Working as a mechanic	0.060	252	3.4
Working as a carpenter	0.065	273	3.7
Working as a mason	0.070	294	4.0
Farm labour	0.065-0.098	290-412	3.9-5.6
Digging with a pick and shovel	0.095	399	5.4
Woodcutter	0.107	449	6.1
Playing billiards	0.026	109	1.5
Playing boules	0.052	218	3.0
Playing golf	0.070	295	4.0

Table 2.1. Calorie intake depending on activity (Cont.)

Physical activity	Calorific consumption		Intensity
	kcal/kg/min	kcal/h	MET (metabolic equivalent)
Recreational swimming	0.085	359	4.9
10 pin bowling	0.098	412	5.6
Playing volleyball	0.101	423	5.8
Horse riding	0.107	449	6.1
Dancing ballet	0.110	462	6.3
Water skiing	0.114	480	6.5
Playing tennis	0.115	482	6.6
Swimming (backstroke)	0.116	486	6.6
Swimming (breaststroke)	0.119	501	6.8
Cycling	0.121	510	6.9
Playing basketball	0.124	519	7.1
Swimming (front-crawl)	0.130	545	7.4
Playing football	0.133	558	7.6
Climbing	0.141	594	8.1
Moderate skiing	0.142	596	8.1
Playing handball	0.143	600	8.2
Skating	0.143	600	8.2
Rowing	0.143	600	8.2
Mountaineering	0.147	617	8.4
Playing squash	0.147	619	8.4
Doing Judo	0.185	779	10.6
Doing Karate	0.185	779	10.6
Swimming (butterfly stroke)	0.200	840	11.4
Jogging	0.214	900	12.2
Intense skiing	0.235	987	13.4
Continuous racing	0.286	1,200	16.3
Walking (3.5 km/h)	0.051	214	2.9
Moderate dancing	0.066	275	3.7
Walking (4-5 km/h : 2.5-3.1 mph)	0.070	295	4.0
Walking/trotting	0.071	300	4.1
Ballroom dancing (waltz)	0.083	347	4.7
Vigorous dancing	0.083	349	4.7
Running (5.5 km/h : 3.4 mph)	0.092	385	5.2
Hiking with backpack	0.097	408	5.6
Ballroom dancing (rumba)	0.101	424	5.8
Running (7.5 km/h : 4.7 mph)	0.154	645	8.8
Walking uphill	0.157	660	9.0
Running (9 km/h : 5.6 mph)	0.300	1,260	17.1
Mountain biking		1,000	7-10
Cross-country skiing		750	7-10
Alpine skiing		450-1,000	7-10

Calorific consumption can be estimated according to the activity, or according to the type of work done (Tables 2.1 and 2.2).

Table 2.2. Calorific intake, according to the type of work done

Type of work	Calorific consumption
Light work (between two hiking trips)	75-100 kcal/hour
Medium work (training)	100-300 kcal/hour
Heavy work	300-500 kcal/hour
Intense work (tough competition)	>500 kcal/hour

Knowing these concepts you can calculate the average calorific ration for a sportsman.

THE ESSENTIAL INGREDIENTS

The human body is composed of different elemental substances (oxygen, carbon, hydrogen, nitrogen, etc.) that combine to give rise to the essential ingredients that will form the cells.

Table 2.3. Essential ingredients

Building blocks	Energy sources	Regulators
Proteins	Glucosides or carbohydrates Lipids or fats	Vitamins Water and mineral salts

Carbohydrates[16, 17]

There are two broad categories of carbohydrates from a nutritional point of view:

- The glucosides that are digested and absorbed in the small intestine (glycaemic carbs) whose main function is supplying energy. They provide 90-95% of the energy supplied by carbohydrate intake.
- Those glucosides that are not digested and pass into the large intestine (dietary fibre) whose main function is the proper functioning of intestinal transit.

Glycaemic carbs

Glycaemic carbohydrates provide cells with carbohydrates, mainly in the form of glucose.

The main glucosides are:

- Monosaccharides: glucose, fructose.
- Disaccharides: sucrose, lactose, maltose.
- Malto-oligosaccharides: maltodextrin.
- Polysaccharides: starch.
- Monosaccharides and disaccharides are grouped under the term "simple sugars".

Glucose

Glucose is the energy source preferred by most cells. Central nervous system cells, red blood cells and some cells dependent on anaerobic glycolysis use it as their almost exclusive source of energy.

A 60 kg adult person can store about 500 g of glucose as follows:

- Blood glucose: 0.8-1 g of glucose per litre of blood.
- Liver glycogen: 70-80 g total. Essential for detoxification functions through glucuronic acid conjugation. Used to maintain normal blood sugar levels between meals.
- Muscle glycogen: 15-17 g per kg of muscle (approximately 300-500 g in total). A carbohydrate rich diet can store up to 33 g of glycogen per kg of muscle. It is mainly used as a source of energy for muscles.

At the beginning of physical activity muscle uses up the glycogen stored in its own cells and when it has exhausted these reserves it uses the liver glycogen. It then obtains energy from body fat and certain amino acids.

Depletion of glycogen stores plays an important role in muscle fatigue. Maximum muscle glycogen exhaustion occurs after prolonged exercise (1-2 hours) at an intensity of between 70% and 85% of the maximum VO_2 (anaerobic threshold).

Blood glucose level represents a balance between the rate of glucose production by the liver and its use by muscles and other tissues. When the rate of glucose use is higher than the rate of production by the liver, the blood glucose level decreases and alters various body functions, especially in the brain.

One and a half hours after the intake of carbohydrates, insulin promotes the incorporation of glucose from the blood into muscle and liver cells, and can cause a drop in blood sugar below 1 g/L. Fatigue and reduced physical performance can occur from 0.8 g/L onwards, especially in individuals with low liver glycogen stores or insufficient gluconeogenesis ("collapse" during exercise, drowsiness after heavy meals).

Glycaemic index and glycaemic load

The concept of glycaemic index was introduced to standardise foods according to their effects on post-meal blood glucose levels. The glycaemic index ranks foods on a scale of 0 to 100 according to the rise in blood glucose level within two hours after eating a particular food. It is expressed as the percentage resulting from the quotient between the area under the glycaemic response curve of a food and the area that produces the equivalent glucose intake. Therefore, glucose is attributed a value of 100 and all other food is compared with that value. The glycaemic index of a food can vary depending on whether it is consumed alone, or with other foods, and how it is cooked. Fibre or fat can significantly reduce the glycaemic index, so the level of glycaemic index in white bread is significantly higher than in wholemeal bread, and in boiled potatoes consumed alone, it is higher than in boiled potatoes consumed with vegetables.

The values for 2,480 foods have been published18. A glycaemic index is considered high if it is above 70, medium if it is between 56 and 69, and low if it is below 55.

The concept of glycaemic load was introduced to quantify the effect of one serving of food on glycaemia; it is based on the glycaemic index but applied to food rations. Glycaemic load is obtained by dividing the glycaemic index by 100, and the result is multiplied by the available carbohydrate content in one serving in grams. The lower the glycaemic load of a food, the lower the increase in blood glucose after eating it. A load is considered to be high when it has a value of 20 or more, average when it is between 11 and 19 and low when it is 10 or less.

Regarding performance, there is no conclusive data showing whether the glycaemic index of foods eaten before exercise affects performance, but it should be noted that the intake of a food with a high glycaemic index can lead to an increase in insulinemia and reactive hypoglycaemia that could decrease performance, so it is recommended not to eat food at least 1 hour before the start of physical exercise.

In practice, the elevation of glycaemia after intake is influenced by both the glycaemic index and the amount of carbohydrates contained in the portion of food ingested.

Regarding health, the intake of foods with a low glycaemic index and load could be related to beneficial effects on the metabolic risk factors of some diseases (diabetes, hyperlipidaemia, etc.), although there is no conclusive evidence.

Table 2.4. Glycaemic index of some foods (Atkinson 2008)

Food	Glycaemic index
Maltose	105 ± 12
Glucose	103 ± 3
Instant mashed potatoes	87 ± 3
Rice 'milk'	86 ± 7
Corn flakes	81 ± 6
Boiled potatoes	78 ± 4
Gatorade ® (6.5% sugars)	78 ± 13
Watermelon	76 ± 4
White bread	75 ± 2
Wholemeal bread	74 ± 2
Boiled rice	73 ± 4
Isostar ® (6% sugars)	70 ± 15
Biscuits	69 ± 2
Wholemeal rice	68 ± 4
Cous-cous	65 ± 4
Table sugar	65 ± 4
Pop corn	65 ± 5
Boiled pumpkin	64 ± 7
Boiled sweet potatoes	63 ± 6
Chips (French fries)	63 ± 5
Honey	61 ± 3
Pineapple	59 ± 8
Muesli	57 ± 2
Potato crisps	56 ± 3

Table 2.4. Glycaemic index of some foods (Atkinson 2008) (Cont.)

Food	Glycaemic index
Green banana	55 ± 6
Coca-cola	53 ± 7
Sweet corn	52 ± 5
Chapatti flat bread	52 ± 4
Mango	51 ± 5
Ice cream	51 ± 3
Banana	51 ± 3
Orange juice	50 ± 2
Spaghetti	49 ± 2
Strawberry jam	49 ± 3
Wholemeal Spaghetti	48 ± 5
Vegetable soup	48 ± 5
Cornmeal crispy bread	46 ± 4
Canned peach	43 ± 5
Orange	43 ± 3
Dates	42 ± 4
Fruit yoghurt	41 ± 2
Apple juice	41 ± 2
Chocolate	40 ± 3
Boiled carrot	39 ± 4
Whole milk	39 ± 3
Skimmed milk	37 ± 4
Apple	36 ± 2
Soya 'milk'	34 ± 4
Lentils	32 ± 5
Chickpeas	28 ± 9
Barley	28 ± 2
White beans	24 ± 4
Soya	16 ± 1
Fructose	15 ± 4

Glycaemic carbohydrate requirements

An intake of 50-100 g/day of glycaemic carbohydrates is sufficient to prevent ketosis and 130 g/day is sufficient to meet the brain's glucose needs, but not to provide the necessary energy in the context of an acceptable intake of fat and protein.

The criteria used to define the nutritional requirements of glycaemic carbohydrates for healthy adult populations are: energy balance; metabolic control, necessary for the maintenance of normal glucose tolerance and insulin sensitivity in both healthy subjects and patients with metabolic syndrome; and decreased risk of type 2 diabetes mellitus. Diets with a low glycaemic index may contribute to a reduced LDL cholesterol.

Based on these criteria, expert consensus conferences propose that glycaemic carbohydrates should represent 45-60% of the total calorie intake (5-7 g per kilo of weight). This, together with a reduction in the intake of saturated fats and fatty acids, improves the metabolic risk factors for chronic diseases (diabetes, cardiovascular diseases, etc.). Also, a higher percentage could lead to digestive disorders and a decrease in appetite for other foods, thereby reducing the intake of protein, lipids, some vitamins and minerals.

High intake (>20% of total kcal) of single sugars increases tooth decay and may increase the concentration of triglycerides and serum LDL cholesterol. Data on negative effects on glucose and insulin response are insufficient. Intake of sugary beverages may increase the risk of weight gain and type 2 diabetes mellitus, but this increased risk in the intake of solid foods with sugars compared to starch intake, has not been found. Simple sugars (honey, sugar, jam) should not exceed 10% of total kcal.[16]

Dietary fibre

25 g/day are recommended to promote intestinal transit. Higher intake (25-40 g/day) is associated with other health benefits: glycaemic control, maintenance of body weight, reduced risk of ischemic heart disease, type 2 diabetes and colon cancer. A meta-analysis on cohort prospective studies showed a 10% decrease in the risk of colorectal cancer for each 10 g per day increase in dietary fibre. A slight effect has also been observed in the control of high blood pressure.

Intake of soluble fibre (pectin, oat bran, guar gum, psyllium) may reduce both total and LDL cholesterol. Insoluble fibre is found in whole grains.

Proteins

Proteins essentially have a forming function, in order to renew the materials used in the cell: however, they can represent a secondary energy source when glycogen is insufficient.

The criteria for recommending protein requirements are based on achieving an equalised nitrogen balance. There is no evidence to support that extra protein intake increases muscle mass in healthy adults. Protein needs include both the total nitrogen as well as the essential amino acids. Using these criteria, expert consensus conferences recommend an intake of 0.66-0.83 g of high quality protein per kilogram of body weight per day. In endurance sports this ranges from 1.2 to 1.7 g/kg of body weight per day. One gram of protein provides 4 kcal.[19]

Proteins are formed from amino acids. Of the 20 amino acids, there are 9 essential amino acids that cannot be synthesised from the others. A 70 kg adult has approximately 10-12 kg of protein; 40-45% in the skeletal muscle, 15% in the skin and blood and 10% in the viscera. Collagen represents about 25% of body protein, which along with myosin, actin, and haemoglobin, adds up to the half of the protein in the body.

High biological value proteins, containing all the essential amino acids, come from foods of animal origin (meat, milk and eggs) although there are vegetables that are rich in protein (soy, legumes, cereals, bread, etc.).

A protein deficit will reduce muscle mass and exercise increases proteolysis; also, when glucose and fatty acids are limited as sources of energy, the body starts to consume its own muscles for energy.

Lipids or fats[20]

Classification and function

Dietary fats consist mainly of:

- Triglycerides, whose molecules are composed of three fatty acids and glycerol, and which constitute the main energy reserves of the organism.
- Phospholipids, which represent less than 1% of dietary lipids, are found in cell membranes, milk and eggs. The most important is phosphatidylcholine.
- Sterols: cholesterol does not produce energy, however it plays a central role in various metabolic processes.

Along with carbohydrates and proteins, fats constitute a major source of energy for the organism, each gram of lipids yielding 9 kcal. They also facilitate the absorption of soluble dietary components, such as vitamins.

Fatty acids have various functions:

- Energy function: they are very energetic molecules and necessary in cellular processes in the presence of oxygen because, due to their high percentage hydrogen atom content, they can oxidise more than carbohydrates whose molecules carry a high percentage of oxygen. When the insulin level or available glucose is low, the body uses fatty acids for energy, thus they are a good energy substrate for muscle during aerobic exercise. The mobilisation of large amounts of fatty acids can cause the liver to start synthesising ketone bodies, which can build up in great quantities, producing ketosis.
- Structural function: they are fundamental components of the phospholipids and sphingolipids that form the cell membrane's lipid bilayer.
- Regulatory function: they are precursors of bioactive molecules (prostaglandins, thromboxanes, leukotrienes, etc.) involved in the regulation and control of various vital processes (regulation of gene expression, regulation of body temperature, blood coagulation, inflammatory response, smooth muscle contraction, etc.).

Fatty acids are classified according to the number of double carbon bonds:

- **Saturated** fatty acids: no double carbon bonds. Can be short-chain or long-chain.
- **Unsaturated** fatty acids: have double carbon bonds.
    - **Monounsaturated** fatty acids: have one double carbon bond: oleic acid (almonds,

  peanuts, hazelnuts, cashews, olive oil, avocado).
  - **Polyunsaturated** fatty acids: have multiple double bonds and are necessary for metabolic integrity.
    - Omega-6: (corn oil, soy, sunflower oil)
      - linoleic acid: expert consensus conferences suggest that their intake should represent 4% of total energy intake.
      - arachidonic acid is synthesised from linoleic acid.
    - Omega-3 (fish, nuts, seeds).
    - linolenic acid: the body synthesises eicosapentaenoic acid and docosahexaenoic acid from linolenic acid. Such acids reduce the concentration of triglycerides in plasma, platelet aggregation, blood pressure and ischemic heart disease.
- ***Cis*** fatty acids: are unsaturated fatty acids in which two double bond hydrogen atoms are on the same side of the molecule. The majority of naturally occurring fatty acids have a cis configuration.
- ***Trans*** fatty acids: are unsaturated fatty acids in which two hydrogen atoms of the double bond are either side of the molecule. Found in industrialised foods subjected to hydrogenation in order to make it thicker (margarine), frying oils, etc.

Essential fatty acids are those that the body cannot synthesise and are required to maintain metabolic integrity; they must be obtained through diet **(linoleic, linolenic)**.

An excess of *trans* saturated or unsaturated fatty acids may increase the risk of ischemic heart disease, so it is recommended that their intake is kept as low as possible.

Lipids are the second most important source of energy for muscle during short-term exercise, while in long-term exercise (e.g. 8-hour walking) they can be the primary source of energy. Their use depends on the degree of exercise and the availability of carbohydrates. After 60 minutes of moderate exercise fat contributes 40% of energy intake, while after 4 hours the contribution increases to 70%. It is the main quantitative energy reserve of the organism since it allows the accumulation of maximum energy in the least weight, since the storage of fat requires almost no water, while the storage of glycogen requires 1 molecule of water for every 3 of glucose.

The lipid reserves of a 70 kg athlete are equivalent to about 94,500 kcal and are distributed in three areas:

- In adipose tissue, in the form of triglycerides (10-20 kg: 6-15% of body weight).
- In muscle, in the form of triglycerides (7-25 micromoles per gram of muscle).
- In the blood, in the form of lipoproteins or as fatty acids bound to albumin (7.5 g).

Daily requirements

There are not enough data to determine the absolute quantity of fats and fatty acids necessary in order to ensure metabolic integrity and human health. Needs have been estimated based on the observation of fat intake in healthy population groups, the observed intake associated with deficiency symptoms, and the amounts necessary to relieve these symptoms.

A very low-fat diet may result in an insufficient intake of polyunsaturated fatty acids, altering the absorption of fat-soluble vitamins and carotenoids, and may be linked to an insufficiency of other essential nutrients such as zinc and group B vitamins.

The composition of fatty acids included in a diet is an important factor for cardiovascular risk. Decreasing the intake of saturated fatty acids and *trans* fatty acids, and increasing the intake of omega-3 long chain polyunsaturated fatty acids from fish oil, reduces cardiovascular risk. The alpha-linolenic acid may also have a specific positive effect but that requires further studies. The most favourable blood lipid profile for reducing atherosclerotic risk is achieved by replacing the intake of saturated fatty acids and trans fatty *acids* with oleic acid, linoleic acid and omega 3 long chain polyunsaturated fatty acids.

Long chain omega 3 polyunsaturated fatty acids can have a discreet beneficial effect on blood pressure, especially at high doses (>0.5 g/day).

The haemostatic function is a complex interaction of several processes, such as endothelial function, platelet aggregation, coagulation and fibrinolysis. Daily intake of more than 1 g of long chain omega-3 polyunsaturated fatty acids can decrease platelet aggregation.

Immune function also includes numerous processes and different cell types. There is evidence to support the anti-inflammatory effect of the omega-3 long chain polyunsaturated fatty acids of fish oil, but at too high a dose (>2 g/day) to be relevant in practice. *Trans* fatty acids from hydrogenated sources can also have adverse effects on the inflammatory profile.

Glucose tolerance and insulin sensitivity: the low number of studies in non-diabetic subjects does not offer sufficient evidence as to whether fatty acids modify insulin sensitivity; in any case, the consumption of saturated fatty acids may impair it and long chain omega 3 polyunsaturated fatty acids may improve it. Total fat consumption can decrease insulin sensitivity as well.

A moderate intake of fat (<35% of total calories) is associated with a moderate reduction in weight and with a prevention of weight gain.

There is not enough evidence about correlation between fat intake and reduction of type 2 diabetes mellitus, cancer, cognitive impairment and dementia.

Based on these criteria, expert consensus conferences recommend that fats represent 20-35% of total calorie intake. Linolenic acid should represent 0.5% of the total caloric intake. The recommended intake of eicosapentaenoic acid and docosahexaenoic acid is 250 mg.

Water[21-25]

Water requirements

The human body is made of 50-60% water, which is a more indispensable element for life than the energy supply. It is necessary for its structural, homeostatic (regulation of body temperature, osmotic balance) and transportative functions.

If the mobilisation and elimination of water produced by effort were not taken into account, it could be calculated that 1 mL of water is needed for each consumed calorie. One hour of intense physical activity at 0 °C entails the loss of 1 litre of water, at 18 °C the loss of 1.5 litres and at 28 °C the loss of 3 litres, although other environmental factors such as humidity must be taken into account.

In conditions of moderate temperature and physical activity, the adequate intake of liquids (water, beverages, water contained in food and water produced by the body's oxidative processes) to maintain desirable osmolarity values and the necessary volume for each calorie consumed, is estimated at 2 litres per day for women and 2.5 litres per day for men. These needs can increase to 12 litres per day under extreme conditions of physical exercise and heat. 20-30% of water is provided by food and 70-80% by drinks.

Water is lost through:

- Urine: this represents 1-2 L/day and can increase up to 20 L/day depending on fluid intake. In case of hyperhydration, urinary volume can be 600-1000 mL/h and in case of dehydration, it can be reduced to 15 mL/h. Physical exercise and heat decrease urine volume; cold and hypoxia increase it.
- Faeces: represent approximately 100-200 mL/day and in case of diarrhoea, this can increase by 5 to 8 times.
- Evaporation:
  - Skin
    - Insensible perspiration: approximately 450 mL/day is lost depending on temperature, humidity, air movement, cutaneous blood circulation and clothing.
    - Sweating: in hot and dry climates this varies between 3 to 8 litres per day. Sweating while exercising in a warm environment can exceed 1.5 L/h, depending on, the intensity and duration of the exercise, clothing, air movement and humidity. Therefore, liquid requirements are 3-6 L/day in temperate climates and 4-12 L/day in hot climates.
  - Lungs: breathing losses depend on the ventilatory volume of the water pressure

gradient, physical activity, O_2 and CO_2 content of the blood, temperature, humidity and altitude. About 250-350 mL/day are lost in sedentary populations and 500-600 mL/day in active people at sea level, increasing by about 200 mL/day at altitudes above 4,300 m, especially if the temperature and relative humidity are low. At 5,500 meters, almost all mountain climbers are dehydrated due to hyperventilation and an increased metabolic rate.

Some indicators of hydration status are:

- Body weight.
- Urine volume: A volume of 100 mL/h indicates good hydration. Volumes above 300 mL/h or below 30 mL/h indicate excessive hydration or dehydration.
- Urine colour: may be used as an indicator but is inaccurate and may depend on diet and medication.
- Thirst is triggered by perceptions (taste, colour, aroma and temperature of the drink) and by physiological mechanisms (increased osmolarity and reduced plasma volume). Thirst is not completely reliable as an indicator of dehydration because, although it appears with the loss of 1-3% of water, its threshold is altered by intense physical exercise.

Dehydration

Is loss of body water.

Depending on the relationship between water and electrolyte loss, it may be:

- Isotonic: water and electrolytes from the extracellular space are lost (vomiting, diarrhoea).
- Hypertonic: water loss exceeds salt loss (inadequate water intake, excessive sweating).
- Hypotonic: more sodium is lost than water (in some cases of sweat or gastrointestinal leakage, or when dehydration is treated with water alone).

Clinical manifestations are:

- Discomfort when standing up from a lying position (orthostatism).
- Muscle weakness.
- Hypotension.
- Tachycardia.
- Flat jugular veins due to fluid deficiency.
- Thirst if water loss is greater than salt loss, or absence of thirst when water or salt are being wasted.

Table 2.5. Effects of dehydration according to percentage of body weight loss

Body weight loss percentage	Signs and symptoms
Greater than 1%.	Increased heart rate and possibly temperature[26]. Temperature increases 0.1 - 0.23 °C for every 1% of body weight loss.
Greater than 2%	Cognitive and motor deficits (fatigue, mood disorders, reaction time, memory, attention, etc.). Activation of the thirst mechanism.
Greater than 4%	Loss of concentration, headache, irritability, drowsiness, increased body temperature and breathing rate, decreased muscle strength.
Greater than 8-10%	May cause death

Hyperhydration and hyponatremia

Excess of water can cause hyponatremia. The expansion of intracellular volume can lead to destruction of muscle cells, central nervous system oedema, pulmonary congestion and death. A healthy individual can excrete 500-1,000 mL of water per hour; if non-urinary losses due to sweating and insensible perspiration are added, that individual can consume up to 1,000-1,500 mL/h before developing water retention and dilutional hyponatremia. In addition to excessive water intake, other risk factors include prolonged exercise for more than 4 hours and following a hydration pattern that is not appropriate for the athlete's body mass index.

In a study of the blood samples of 488 runners who performed in the Boston Marathon, hyponatremia was found in 13% (Na^+<135 mmol/L) and severe hyponatremia in 0.6% ($Na^+<120$ mmol/L). Two runners in good health died of secondary cerebral oedema and hyponatremia. Hyponatremia was associated with considerable weight gain during the race due to water intake and a long run time (4 hours). In ultramarathons, the incidence of hyponatremia associated with exercise is 30%-51%.[27-29, 30]

Perhaps the axiom "drink-without-thirst" does not take into account the global hydrosaline balance (osmolarity, ions, etc.). In the mountains it is not easy to find water and the dry environment stimulates dehydration, producing hyperosmolarity and hypernatremia, so dehydration (heat stroke, etc.) is much more frequent than hyponatremia. Nevertheless, hyponatremia has been reported in hikers who visited the Grand Canyon National Park, where the emergency response protocol includes a rapid determination of serum sodium with portable analysers to distinguish between dehydration and hyponatremia.[31] A guide to knowing the hydration status is to observe urine colour; it should be light yellow; if it is highly concentrated it indicates a lack of water, and if it is transparent it could indicate excess water.[32]

Prevention of hyponatremia associated with exercise[30]

Current recommendations (2005) to avoid dehydration and hyponatremia during long term endurance activities (running, training, physical work, etc.) are based on avoiding hyperhydration, excessive salt supplementation and monitoring body weight:[33, 34]

- Drink enough to compensate for fluid loss: minimise weight loss during exercise, but also prevent weight gain from excessive hydration. If a weight gain of more than 2-4% is observed during exercise, water and sodium intake should be reduced until initial weight is restored **(A)**.
- The USA Track & Field axiom is currently: "thirst is a guide to drinking" and not "drink even if you are not thirsty" **(B)**.
- Eat a balanced diet regarding salinity. Sodium supplementation is not recommended if the exercise duration is less than 18 h **(B)**, since saline supplements have not been shown to prevent hyponatremia in exercise lasting less than 18 h, nor have such supplements shown an effect on plasma sodium concentration when athletes drink according to their thirst.

Prehospital treatment of exercise-associated hyponatremia[30]

- Restriction of hypotonic or isotonic fluids until the patient initiates diuresis **(A)**.
- Oxygen therapy to maintain a saturation of 95% oxygen **(B)**.
- If cerebral oedema symptoms occur (headache, nausea, vomiting, confusion, clouding, coma, convulsions) or non-cardiogenic pulmonary oedema symptoms occur (respiratory failure), plasma sodium should be measured urgently **(A)**.
- If there is no disturbance in consciousness, it is advisable to limit fluid intake, eat salty foods and stay under observation for 1 hour, as the water remaining in the gastrointestinal tract can be rapidly absorbed and signs of hyponatremia can develop.
- If there are more severe neurological symptoms than headache, administer a hypertonic saline solution (Na 9%), for example: 3-4 stock cubes in 125 mL (half a glass) of water **(B)**.
- If the individual does not tolerate oral intake of hypertonic saline solutions or deteriorates, the administration of 100 mL of 3% hypertonic saline (51 mmol sodium) by peripheral vein is advised in bolus in less than one minute, which is expected to increase the serum sodium concentration by 1-2 mmol/L, and may be repeated every 10 minutes if there is no clinical improvement up to a maximum of 3 doses, with the aim of increasing the serum Na concentration by 4-5 mmol/L and reversing the cerebral oedema **(A)**.

Hospital treatment of hyponatremia associated with exercise[30, 35]

- Plasmatic sodium measurement **(A)**.

- Anamnesis and physical examination aimed at detecting signs and symptoms of cerebral and non-cardiogenic pulmonary oedema. Imaging techniques should not delay the infusion of hypertonic saline (A).
- Determination of urinary sodium and plasma and urinary osmolality (C).
- Oxygen therapy to maintain 95% oxygen saturation (B).
- Restriction of hypotonic or isotonic fluids until the patient initiates diuresis (A).
- If hypovolaemia is confirmed by urea plasma elevation and urinary Na <30 mmol/L (B).
- If the serum sodium concentration is less than 125 mmol/L or there is symptomatic hyponatremia, it is advisable to administer 3% hypertonic saline (51 mmol sodium) in 100 mL bolus by peripheral vein in less than one minute, which is expected to increase the serum sodium concentration by 1-2 mmol/L, and may be repeated every 10 minutes if there is no clinical improvement up to a maximum of 3 doses, with the aim of increasing the serum Na concentration by 4-5 mmol/L and reversing the cerebral oedema (A).

Minerals

The most important minerals are: sodium, chlorine, potassium, calcium, phosphorus, iron, magnesium, iodine, sulphur, etc. Trace elements are minerals that are required in trace quantities: fluorine, zinc, cobalt, copper, nickel, lithium, barium, aluminium, manganese, etc.

They are essential for certain vital metabolic reactions. They also make up part of the skeleton (calcium and phosphorus), blood cells (iron, cobalt, and copper) and thyroid hormones (iodine). They control the balance of water and electrolytes (potassium, chlorine, sodium, and calcium) and are necessary for proper functioning of nerve cells (calcium and magnesium).

A significant lack of minerals is rare due to the small amounts required, but a certain lack of iron and magnesium can already be found in many sportspeople due to the 10 hours a week of training, especially in runners.[17]

Iron is necessary for the formation of oxygen transport proteins (haemoglobin and myoglobin) and enzymes involved in energy production. Oxygen transport capacity is essential for both performance and the proper functioning of the nervous and immune systems. Iron deficiency, with or without anaemia, can impair muscle function and limit work capacity. Iron requirements in endurance athletes can increase by up to 70%,[17] and they may need 20-40 mg/day. In the case of the haemoglobin and/or mean corpuscular volume suggestive of iron deficiency anaemia, ferritin is the most appropriate way to determine the status of iron stores. If you give an iron supplement, you should consider its potential overdose toxicity and its interaction with zinc and copper absorption.[36-38] Haem iron is the one used to form red blood cells. It is present in foods of animal origin and 30-40% of it is absorbed. Iron from plant products is not haem, only 4% of it is absorbed, but 8% can be absorbed if taken with vitamin C.

Calcium is especially important for the growth, maintenance, and repair of bone tissue, maintenance of bone calcium levels, regulation of muscle contraction, nerve conduction and clotting. Moderate physical activity promotes bone calcification, while high intensity exercise can have the opposite effect and cause osteoporosis.

Zinc plays a role in the growth and repair of muscle tissue, energy production and immune status.

Magnesium is important for cellular metabolism and regulates cell membrane stability and neuromuscular, cardiovascular, immune, and hormonal functions.

Daily sodium requirements, which are generally around 3-5 g, increase in case of profuse sweating or diarrhoea. Sports drinks often provide 0.5-0.7 g per litre.

The daily potassium requirement is 0.5 g and increases with effort, so it may be advisable to eat food containing potassium (bananas, etc.) before such effort.

Table 2.6. Foods rich in minerals

Mineral	Food
Iron	Meat, fish, eggs, seafood, offal, blood products, cereals, lentils, white beans, pistachios, egg yolk and spinach
Calcium	Milk and milk products
Phosphorus	Fish, legumes, nuts, dairy products, meat and egg yolk
Potassium	Fruit (orange or banana), legumes, vegetables, chocolate and nuts
Magnesium	Leafy green vegetables, fruit (bananas and cherries), grains, and legumes

Vitamins

These are substances that cannot be synthesised by the organism and which, in very small amounts, are necessary for metabolism.

Vitamin deficiency can lead to serious disease, but their excess can also result in the same; for example, excess vitamin C can lead to gastritis, excess vitamin A can lead to endocranial hypertension, excess vitamin E can increase the risk of dying from subarachnoid haemorrhage, and excess beta carotene can increase cardiovascular death rates. Administering beta carotene, vitamin A and vitamin E supplements may increase mortality.[39]

B complex vitamins are involved in energy production during exercise, red blood cell production, protein synthesis, and repair and maintenance of tissues, including the central nervous system.

Vitamin D is needed for calcium absorption, regulation of serum calcium and phosphorus levels and proper bone calcification. It also

Table 2.7. Foods rich in vitamins and recommended intakes

Vitamins	Sedentary	Athlete	Food
B_1 or thiamine	1.5 mg	5-10 mg	Meat, milk, legumes and cereals
B_6 or pyridoxine	4 mg	15-30 mg	Meat, liver, egg yolk, and cereals
B_{12} or cyanocobalamin	2-5 µg	10-20 µg	Meat and eggs
C or ascorbic acid	75-100 mg	200-500 mg	Citrus fruits, kiwi, vegetables, potatoes and fresh vegetables
B_2 or riboflavin	2.5 mg	10-15 mg	Meat, milk, eggs, cereals and green vegetables
B_3 or PP	20 mg	30-50 mg	Fruits, vegetables, fungi, and seeds
B_5 or pantothenic acid	10 mg	20-30 mg	Poultry meat, eggs, broccoli, tomatoes, potatoes, legumes
B_8 or H or biotin	5 mg	10-20 mg	Poultry meat, eggs, broccoli, tomatoes, potatoes, legumes
B_9 or folic acid	10-15 mg	15-40 mg	Meat, liver, eggs, spinach and green vegetables
C_2 or P	10-20 mg	20-40 mg	Citrus fruits
A or retinol (*)	2,000-6,000 IU	50,000 IU (nocturnal activities)	Butter, milk, egg yolk and carrot
D or cholecalciferol (*)	400 IU	400 IU	Oily fish and butter
E or tocopherol	10-30 mg	30-50 mg	Vegetable oil, margarine, wheat germ, sunflower seeds and eggs
K or menadione (*)	75 µg	75 µg	Vegetables, cereals, milk and meat
F or indispensable fatty acids (linoleic, linolenic or arachidonic acid) (*)	1% of total calories	8-10% of total calories	Are the omega-3 fatty acids

(*) Fat-soluble; it is not necessary to take them every day because they accumulate in body fat.

regulates homoeostasis of the nervous and skeletal muscle systems.

The antioxidants beta-carotene, vitamins C and E and selenium protect cells from oxidation. The practice of physical exercise significantly increases oxygen consumption, which gives rise to an increase in the production of free radicals. Sports training and its resulting improvement in physical qualities, increases antioxidant enzymes by protecting the body from oxidative stress **(A).** Sportspeople may have a more developed endogenous antioxidant system than sedentary people.[17] The evidence that antioxidant supplements improve performance is minimal. Vitamin E may reduce lipid peroxidation during exercise and have a limited effect on strength training, so that might improve recovery in some athletes, although there is insufficient data.[17, 40]

Vitamin C does not seem to have an effect on performance.[17] In athletes who routinely engage in prolonged and strenuous exercise, increased vitamin C intake (200-500 mg./d) may improve immunity, decreasing the incidence of upper respiratory tract infections **(B).**

There is no solid data to justify the use of vitamin supplements above the contributions recommended for increasing performance **(A).**[39]

THE BALANCED DIET

A diet is balanced when it provides the body with a variety of foods in the right quantities and of the required quality. It is more important to habitually follow a balanced diet than to try and compensate for nutritional deficiencies in a diet consumed during those days when sporting activity takes place.

A food ration is considered balanced when it contains the following ratio of essential ingredients:[16, 19-21]

- Glucosides: 45-60% of total energy intake (simple sugars <10%).
- Lipids: 20-30% of total energy intake.
- Protein: <15% of total energy intake.

To recommend a balanced diet, foods are usually grouped according to the essential ingredients they contain.

The basic groups are:

- The group containing bread, potatoes, rice and pasta and starches (glucosides and fibre).
- The group containing seasonal and green vegetables (fibre, vitamins, and minerals).
- The group containing fruits (glucosides, vitamins, minerals and fibre).
- The group containing vegetable fats (lipids).
- The group containing milk and its derivatives (protein, calcium, lipids and carbohydrates).
- The group containing meat, fish, eggs and substitutes (protein).

Daily recommendations[41]

Bread, potatoes, rice and pasta are the main source of carbohydrates and, therefore, the main source of energy. They also provide iron,

Table 2.8. Daily food recommendations

Food groups	Recommended frequency	Weight of each serving (raw and net)	Domestic measures
Bread, potatoes, rice and pasta	4-6 servings per day (plus integral forms)	60-80 g of pasta, rice 40-60 g of bread 150-200 g potatoes	1 dinner plate 3-4 slices or a bagel 1 large potato or 2 small
Seasonal and green vegetables	A minimum of 2 servings per day	150-200 g	1 bowl of mixed salad 1 bowl of cooked vegetables 1 large tomato, 2 carrots Side salad = ½ serving
Fruit	Minimum of 3 servings per day	150-200 g	1 medium-sized piece, 1 cup of cherries, strawberries, etc., 2 slices of melon,
Olive oil	3-6 servings per day	10 mL	1 tablespoon

Table 2.8. (Cont.) Daily food recommendations

Food groups	Recommended frequency	Weight of each serving (raw and net)	Domestic measures
Milk and milk products	2-4 servings per day	200-250 mL of milk 200-250 g of yogurt 40-60 g ripened cheese 80-125 g of fresh cheese	1 cup of milk 2 units of yogurt 2-3 slices of cheese 1 individual portion
Fish	3-4 servings a week	125-150 g	1 individual fillet
Lean meats, poultry and eggs	3-4 servings each week. Alternate your consumption	100-125 g	1 small steak, 1 quarter of chicken or rabbit, 1-2 eggs
Legumes	2-4 servings a week	60-80 g	1 dinner plate
Nuts	3-7 servings a week	20-30 g	1 handful or individual serving
Cured and fatty meats	Occasional and moderate		
Sweets, snacks, soft drinks	Occasional and moderate		
Butter, margarine, and pastries	Occasional and moderate		
Drinking water	4-8 servings per day	200 mL approx.	1 glass or 1 small bottle
Beer or wine	Optional and moderate consumption in adults	Wine: 100 mL Beer: 200 mL	1 glass or 1 jug

vitamin B and proteins. Whole grain products are richer in fibre, proteins and vitamins. Flour, semolina and pasta contain 75% starch and 9% protein. Bread contains 55% glucosides and 7% protein. In sports nutrition, biscuits and well-baked, toasted, crusty hard bread are preferable, as the starch has undergone a process of transformation and is more digestible. Biscuits have more calories (400 kcal/100 g) and are more digestible.

After bread, potatoes are the main source of glucosides and have a nutritional value similar to pasta and rice. They also have potassium and vitamin C if cooked with the skin on.

Seasonal and green vegetables are rich in water (80%), vitamins A and C, minerals (especially potassium) and fibre. They have a calorific intake of 20-100 kcal/100 g, depending on the amount of glucosides (2-15%).

To avoid loss of nutrients, it is advisable to cook them with the skin on, cut into large portions, at a very high temperature for a short time, with little water and reusing the water to make soups and purées. An acidic environment protects the vitamins, so it is advisable to add a few drops of lemon juice or vinegar.

Fruits are rich in vitamins A and C (especially citrus fruits) and minerals (especially calcium and potassium) have more sugars than vegetables and their skin is rich in fibre. Fruits and tart berries (raspberries, strawberries, etc.) contain 5-10% glucosides, the seeds and stones 12-15%, and bananas, grapes, and figs 20%. The calorific value varies from 40 to 90 calories per 100 g.

Olive, sunflower and soy oils are an important source of supplementary energy (900 calories per 100 g) and also contribute essential fatty acids and vitamin E. For cooking it is preferable to use olive oil because it resists high temperatures better. Raw, it can be used for everything.

Milk and derivatives are the main source of calcium, which is in excellent condition for use as it is accompanied by phosphorus and vitamin D. It also contains vitamins A, D and B2, in addition to high biological value protein (3,5%), sugars (5%), fat (whole milk 3.4%, semi-skimmed 1.5%, and skimmed <0.3%). It also contains approximately 250 mcg/L of iodine, which means that a glass of milk provides 30% of the recommended daily requirements. Semi or skimmed milks have almost no vitamins A and D when the fat that transports them is removed, although some brands add them back later. Milk is only deficient in vitamin C and iron and it provides about 70 calories per 100 g.

Yogurt is milk fermented by bacilli acids that contribute to better calcium utilisation and regulate intestinal fermentation processes.

As for cheeses, their concentration of nutritional elements depends on their concentration of water, however they are rich in vitamin A and provide 100-400 calories per 100 g.

Meat, fish, eggs and substitutes are rich in protein, fat, iron, calcium, iodine, vitamin B_1, B_2, niacin and folic acid.

Meat contains 15-20% protein and is rich in phosphorus, iron and vitamin B_1. It provides 170 calories per 100 g.

In relation to meat, fish has small amounts of calcium, iodine, sulphur and fluorine. Oily fish is rich in unsaturated fats and vitamins A and D. It provides 80-200 calories per 100 g.

Egg white has 14% protein with the most balanced amino acid ratio of all our food. These proteins are used only if the egg is cooked. The lipids (12%) are concentrated in the yolk, as well as iron, potassium, calcium, and vitamins B_1, B_2, and D.

Legumes, aside from being rich in carbohydrates, are also an important source of vegetable protein. Their consumption recommended 2-3 times per week. The quality of plant proteins can be improved if they are mixed with animal proteins (pulses with meat, fish or eggs), or if two complementary vegetables are combined (pulses with cereals: lentils with rice, etc.).

Dried fruits (raisins, dates, figs, prunes, or apricots) are very rich in carbohydrates (60-70%) and have a high energy value (250-300 kcal/100 g). Rich in minerals and easy to digest, they provide an excellent glucose and mineral supplement to consume during effort, particularly dates and figs. They should be chewed with plenty of saliva so that their sweetness does not cause thirst.

The oleaginous fruits (olives, walnuts, hazelnuts, almonds or peanuts) contain 50-60% lipids, 15-20% glucosides and 15-20% protein. They contribute 600 calories per 100 g, and have an important content of essential fatty acids, vitamin B1 and potassium. Their digestion is slow, so it is best to take them at the end of exercise or during long breaks (2-3 hours).

With respect to **cured meats**, the only ones that sportspeople are not discouraged from eating are ham and fat-free sausages.

Regarding **animal fats**, it should be remembered that **butter** provides 760 kcal/100 g and is a primary source of vitamin A for the body; the other animal fats have no vitaminic interest and are difficult to digest.

Margarines are hydrogenated oils and emulsified with water or milk, contribute 760 calories per 100 g and they have carotene and vitamin E. These hydrogenated oils, such as sunflower oil, lose the advantages of polyunsaturated oils.

Sugars are of interest to mountain sports. Beet or cane sugar and sweets have a high energy value (400 kcal/100 g), but their input should not exceed 10% of total calories. Honey is very high in energy (320 kcal/100 g), has fructose and glucose and is assimilated quickly, but it can be a laxative. Chocolate has a high calorific value due to its high content of lipids (500 kcal/100 g) and vitamin B, but in excess it can be indigestible and impair joint function due to its calcium oxalate content. Jams are rich in glucosides and have a high energy value (250-300 kcal/100 g).

As regards the eating habits of the general population, it is recommended to:

- Increase the intake of complex carbohydrates (bread, pasta, or rice) without increasing calorific intake, and decrease meat consumption.
- Increase the consumption of fruits and vegetables, and foods rich in fibre.
- Avoid excess fat, especially of animal origin
- Decrease the consumption of simple sugars
- Moderate the consumption of alcohol.

NUTRITIONAL RECOMMENDATIONS FOR SPORTSPEOPLE[17, 42]

The American College of Sports Medicine, the associations of American and Canadian Dietetics, and the Spanish Federation of Sports Medicine give the following recommendations for sportspeople:

Diet in general

People who have a balanced diet with all the necessary nutrients and sufficient energy intake to maintain weight are best suited to physical exercise. Insufficient energy intake can cause loss of muscle mass, menstrual disorders, decreased bone mass, increased risk of fatigue, injury and illness **(A).**

Before exercise, it is advisable to have a meal that contains enough fluid to maintain hydration; is low in fat and fibre to facilitate gastric drainage and minimise gastrointestinal problems; has a high percentage of carbohydrates to maximise blood glucose levels; has a moderate protein content; and consists of foods that the sportsperson usually tolerates well.

Carbohydrates

Carbohydrates are important to maintain a proper blood glucose levels during exercise and for replacing consumed muscle glycogen. The recommended intake is 7-12 g per kg of weight per day.

Before physical activity. Carbohydrate consumption before physical activity can increase performance **(A).** It is recommended to consume 200-300 g of carbohydrates three to four hours before the activity. Consumption of 9-12 g/kg/day four days prior to competition is recommended with the intention of increasing glycogen reserves. The consumption of carbohydrates, especially those with a high glycaemic index, shortly before the start of physical activity can lead to an increased risk of hypoglycaemia.

Figure 2.1. Ski mountaineering race.

During physical activity. Carbohydrate consumption during exercise lasting more than one hour improves the metabolic response and increases performance. This can be achieved by providing carbohydrates in the rehydration drinks. For optimal absorption and rapid gastric emptying, the osmolality of the drink, the concentrations of carbohydrate (max. 300-350 kcal/L) and sodium (max. 40-50 mmol/L), and drinking the right amount **(A)** are important. The addition of potassium (maximum 10 mmol/L) helps to retain water in the intracellular space **(B).** Therefore, drinks with 6-8% carbohydrates are recommended, since if the carbohydrate concentration is higher than 9%, gastric emptying slows down, water absorption is delayed and blood insulin increases. With regard to performance improvement, there is no difference between the contributions of glucose, sucrose or maltodextrin in these drinks. Fructose should not be the predominant carbohydrate because its transformation into blood glucose is slow and, therefore, does not increase short-term performance; in addition, it can cause gastrointestinal disorders (abdominal pain or diarrhoea). If fructose is present as a second ingredient (sweetener) it does not have adverse effects.

The optimum temperature for absorption of the liquid is body temperature, the consumption of cold drinks can be useful for its regulatory effect on temperature, as its effect on gastric emptying is small and transient 43. In high mountains and/or low temperatures, higher temperature beverages may be recommended to reduce the body cooling rate.

Carbohydrate gels combined with a couple of drinks of water provide 4%-8% carbohydrates, ideal for gastric emptying, while energy bars need almost half a litre of water. From the nutritional point of view, energy bars have a calorific intake of 250-500 kilocalories (kcal), with a 60-80% carbohydrate content, 4-15% protein, and 3-25% fat, plus vitamins and minerals.

In longer-term activities, an intake of 0.7 g of carbohydrates per kg of body weight per hour (60 g/h or 600-1200 mL/h of a solution containing 6-8% carbohydrates) helps to replace those consumed and delay fatigue. It is more advisable to drink 10-250 mL of fluid every 10-20 minutes because consumption of a given amount of carbohydrates after two hours of exercise is not as effective as the consumption of the same amount at 15-20 minute intervals during the same activity.

After physical activity. The consumption of high carbohydrate content diets (>65% of the energy intake; 0.8-1 g of carbohydrates per kg) during the first 30 minutes after the end of physical activity, and then from that point onwards every two hours up to 6 hours, increases the plasma glucose and insulin concentration and achieves high levels of muscular and hepatic glycogen. The period of between 30 minutes and 2 hours, when the body is most able to absorb nutrients, is also called the "metabolic window".

Table 2.9. Recommendations for carbohydrate intake per hour depending on the duration of the physical activity and type of food or drink in use

Duration	Needs	Food	Drink
<1 hour	30 g CH/h	No	Isotonic drink (6% Carbs) 500-750 mL/ hour
1-3 hours	60 g CH/h	Yes Gel/ Wine gums 1 Gel/ every 45-60 min.	Isotonic drink (6% Carbs) 500-750 mL/ hour
>3 hours	60-90 g CH/h	Yes Gel/ Wine gums 1 Gel/ each 60 min.	Isotonic drink (7-9% Carbs) 600-900 mL/ hour

The type of carbohydrate affects glycogen synthesis after exercise; glucose with fructose is more effective than fructose alone **(A).**

Lipids

Endurance sports, when increasing the level of training, increase the energy obtained from fatty acids **(A).** Fat must provide 20-35% of the energy; in addition to being a source of energy, it is important as a source of fat-soluble vitamins and essential fatty acids. A fat intake providing less than 20% energy does not improve performance and may be detrimental. It is recommended not to consume significant amounts of fat shortly before and during physical activity as this slows down gastric emptying and produces discomfort.

Proteins and amino acids

Protein requirements range from 1.2 to 1.7 g per kg of body weight per day for endurance and/or strength sports. It is preferable to ingest protein as part of a varied diet than to take amino acid supplements.

There is a cause-effect relationship between daily protein intake and the increase or maintenance of muscle mass. Whey proteins increase glycogen deposition and have a marked anabolic character, so their intake is important after long-term effort **(A).**

Intake of branched-chain amino acids (BCAA) before and after exercise has an anti catabolic effect, reducing exercise-induced muscle damage, and an anabolic effect, stimulating protein synthesis **(B).** Leucine at a dose of 0.05-0.1 g/kg body weight/day may be useful for recovery.

Taurine is involved in the skeletal muscle excitation-contraction mechanism, improving the transmission of electrical signals to the muscle fibres and muscle performance **(B).**

Glutamine might have an anti catabolic effect in sportspeople whose activity involves a large amount of muscle destruction **(B).**

Glycine propionyl L-carnitine (GPLC) might increase the anaerobic threshold, reduce lactic acid production and accumulation in endurance athletes, maintain muscle carnitine content at rest, and increase nitrous oxide production, thereby improving performance and recovery after physical exercise **(B).**

Water and minerals

Physical activity increases sweat production resulting in loss of water and electrolytes (Na, Cl) especially in hot and humid conditions. Dehydration worsens performance, so it is important to restore lost fluids **(A).**

Sportspeople are generally advised to drink enough water so that their urine is a pale yellow colour.

It is advisable to drink approximately 5-7 mL/kg body weight of fluids (400-600 mL) at least 4 hours before exercise.

After exercise, to recover dehydration losses, it is advisable to drink 450-675 mL of fluids for every 0.5 kg of weight lost as a result of said exercise. A useful method is to weigh yourself and replace 150% of weight lost with a slightly hypertonic drink (juice, soup, etc.).

In general, the recommendations for mineral intake in sportspeople are similar to the general population **(A).** Electrolytes are minerals found in bodily fluids. When sweating, sodium is the first electrolyte lost (more than one gram for every quarter litre of sweat). Excessive rehydration with water alone can cause hyponatremia, so it is recommended to ingest water with electrolytes **(A).** The sodium level of sports drinks should be the same as that lost through sweating, but they would be too salty, therefore a quantity of 0.5-0.7 g of sodium per litre of liquid is considered sufficient to replace the sodium lost through sweating. In most cases, sodium lost through sweat is replenished by a normal diet. The consumption of salty drinks or foods helps electrolyte recovery. Muscle cramps are associated with dehydration, lack of electrolytes and muscle fatigue.

Vitamins

The need for taking vitamin supplements with a proper diet has not been demonstrated **(A).** Vitamin C supplements (200-500 mg/d) may boost the immune system if high intensity exercise is performed, decreasing the incidence of upper respiratory tract infections **(B).**

Stimulants

Stimulant drinks in general have not shown performance improvements and, in turn, can cause severe cardiac arrhythmias.

Administering caffeine can improve alertness, concentration, reaction time, motor learning and short-term memory. Caffeine at a dose of 200-300 mg (3-6 mg/kg) can improve performance in endurance activities. Administering 3 mg/kg of caffeine one hour before exercise increases endurance, while 4 mg/kg reduces the perception of effort **(A).**

The consumption of more than 360-500 mg of caffeine can have a diuretic effect (1 cup of coffee contains 60-120 mg of caffeine; 1 cup of tea contains 25-100 mg of caffeine).[45-49]

RETENTION OF FOOD IN THE STOMACH

The main factors affecting gastric emptying are the volume of the gastric content and the calorific content of the gastric content. Above 600 mL in volume, the rate of gastric emp-

Table 2.10. Time food remains in the stomach

Time (hours)	Food
1-2 hours	Water, coffee, tea, cocoa, fat-free broth, beer, boiled egg, boiled rice or boiled freshwater fish.
2-3 hours	Milk, potatoes, vegetables, fruit, white bread, sea fish or veal.
3-4 hours	Wholemeal bread, potato crisps, cabbage, carrot, radish, spinach, apple, grilled steak, ham, boiled chicken or omelette.
4-5 hours	Legumes, stewed or fried poultry or beef.
5-6 hours	Mushrooms, tuna or oil.
6-8 hours	Sardines, pâté or pork.

tying ceases to be stimulated and starts to reduce.

To facilitate digestion, chew food properly, do not drink too much liquid during meals and keep in mind that fats, sweets and foods of animal origin spend more time in the digestive system. Generally, the more calories contained, the more time spent in the stomach. The body cannot absorb more than 100 g of carbohydrates or 400 kcal per hour during exercise without inhibiting gastric emptying.

Also, it is better to have 4-5 meals a day with a smaller quantity of food.

If you are participating in a running race, the acceptable rule is to stop eating 4 hours before the start.

Table 2.11. Composition of foods used frequently in the mountains (value per 100 g raw)

Food	Proteins (g)	Lipids (g)	Glucosides (g)	Calories (kcal)
Meats (average)	20	10		170
Chicken	20.5	4.3		121
Ham	22	22		302
Cured meats (average)	31	39		475
Oily fish (average)	20	10		170
Semi-oily fish (average)	18	7		135
Lean fish (average)	18	1		81
Sardines in oil	20	12		188
Eggs	13	12	0.6	162
Whole milk	3.5	3.4	4.6	68
Skimmed milk	3.5	0.1	5	36
Condensed milk	10	10.4	54	350
Whole milk powder	25	26	37	500
Yoghurt	3.4	1.5	1	25
Unripen cheese	10	10-20	4	100-220
Soft cheese	18-25	16-23	3	200-340
Pressed cheese	27-29	20-30	2-3	300-400
Melted cheese	18	22	2.5	280
Butter	0.7	83	0.6	752
Vegetable oil		99		900
Margarines	0.1	83.5	0.4	752
Almonds, hazelnuts, walnuts	17	56	17	640
Bread	7	0.8	55	255
Wholemeal bread	8	1.2	49	239
White rice	7.6	1.7	77	354

Table 2.11. (Cont.) Composition of foods used frequently in the mountains (value per 100 g raw)

Food	Proteins (g)	Lipids (g)	Glucosides (g)	Calories (kcal)
Cereals (unsweetened)	7.9	0.4	85.3	386
Cereals with honey	4.4	0.2	91.3	386
Sweet biscuits	7	14.5	74	436
Salted crackers	10.8	12.5	75.8	440
Cupcakes	6.4	22	65.5	469
Pasta	12.8	1.4	76.5	375
Potatoes	2	0.1	19	86
Legumes	23	1.5	58	338
Seasonal vegetables	2.5	0.3	8	40
Salad	1.5	0.3	5	29
Tomato	0.9	0.3	4	22
Citrus fruits	0.7	0.2	10	45
Grapes	1	1	17	81
Bananas	1.4	0.4	20	89
Other fruits	0.5	0.3	14	62
Sugar			100	400
Jam	0.5	0.1	70	283
Honey	0.5	0.2	75	304
Chocolate	7	24	64	500

Table 2.12. Composition of common mountain foods (value per 100 g cooked)

Food	Proteins (g)	Lipids (g)	Glucosides (g)	Calories (kcal)
Semolina soup	1.12	1.02	3.3	27
Noodle soup	3.06	4.06	7.65	83.8
Noodles with tomato	3.6	6.4	21.37	157.5
Macaroni	2.1	10.38	13.1	154
Rich Tea biscuits	6.68	7.58	70.77	378
White rice	3	10.8	18.33	182.5
Baked potatoes	2.9	0.38	31.73	142
Mashed potatoes	1	7.44	6.7	97.8
Chips/French fries	2.1	14.8	46.5	327.6
White beans	3.9	5.38	11.24	109

Table 2.12. (Cont.) Composition of common mountain foods (value per 100 g, cooked)

Food	Proteins (g)	Lipids (g)	Glucosides (g)	Calories (kcal)
Stewed lentils	6.6	3.5	15.6	120
Boiled Swiss chard	0.96	6.52	0.51	64.6
Boiled spinach	2.9	4.3		51.2
Boiled cauliflower	1.5	3.7	5.1	60
Lettuce	1.44		0.8	8.9
Tinned peas	4.2	1.3	6.9	56
Green beans	2.4	6.1	2.4	74
Grilled beef	16.9	10		158
Breaded hake	15.3	3.3	5.1	111
Omelette	13.4	16.4		201

WATER PURIFICATION[50]

Water is an important route for transmission of diseases. A variety of media can be used for water purification (Table 2.13).

Bottled water is as safe as its source. If the source is infected, the water will be infected too. Carbonated water is sufficiently acidic to kill bacterial contaminants.

There are various chemical treatments to purify water. The effectiveness depends on the concentration of the product, the temperature of the water and the contact time. In order to avoid the bad taste of water subjected to chemical purification, it is necessary to add a good tasting substance (orange, etc.) after disinfecting the water to avoid any interaction with the disinfectant.

In European mountains, where water pollution is due to bacteria or viruses and there are not likely to be any protozoa or worms, you can use several methods:

Table 2.13. Procedures for purifying drinking water

Procedure	Virus	Bacteria	Protozoa	Worms
Boil 10 minutes	Yes	Yes	Yes	Yes
Chlorine (bleach)	Yes	Yes	No	No
Iodine	Yes	Yes	Yes (except *Cryptosporidium*)	No
Silver salts	No	Yes	No	No
Katadyn filter	No	Yes	Yes	Yes
Guardian™ Purifier	No	Yes	Yes	Yes
MSR Water-Works® filter	No	Yes	Yes	Yes
Timberline filter	No	No	Yes (except *Cryptosporidium*)	Yes
Filopur® filter	No	No	Yes (except *Cryptosporidium*)	Yes
Iodised resin PUR filter	Yes	Yes	Yes	Yes

- In the first place, filtering the water with some fabric, for example with a micro-fibre cloth.
- Boil the water for 5-10 minutes.
- Use chlorine-based products, such as household bleach, at a dose of 8-10 drops per litre of water; or products that are already marketed in light weight, low volume containers. Leave to stand for 30 minutes.
- Use products based on iodine. Povidone-iodine (PVP-I) contains 10% iodine and requires four drops per litre. It should be avoided by pregnant women, people with iodine allergy or diseases of the thyroid. The time to wait before using the water depends on its clarity and temperature: if the water is clear and is at 5 °C, wait 30 minutes; if it is at 15 °C, wait 15 minutes; if the water is dirty, wait for double the time. If you then add 50 mg of vitamin C, it enhances the flavour.
- Use tablets based on chlorine ions and silver (e.g. Katadyn® Micropur Forte) because of their convenience. You need to wait 30 minutes for bacteria and viruses and 2 hours for *Giardia*.

3 PHYSICAL PREPARATION

THE PHYSICAL FORM

Physical fitness is the ability to perform daily activities with rigour and diligence, without fatigue and with sufficient energy to enjoy leisure activities, and to cope with eventual emergencies. Its most relevant components are endurance, strength, flexibility, balance, speed and coordination. It is acquired through physical exercise, which is the planned, structured and repetitive performance of physical activity.

Practicing mountain sports without sufficient physical form not only prevents enjoyment of the activity, but can also even compromise the safety of the individual. Likewise, the non-professional practice of a sport should be a source of balance and pleasure, not a source of stress.

It is not the purpose of this document to explain training methods, as they are already sufficiently developed in the excellent existing manuals,[51] but only to comment on some basic concepts. A medical check-up including stress testing and echocardiography is recommended prior to any training program, if possible.

PHYSICAL EXERCISE AND HEALTH[52]

Prescribing physical exercise is especially helpful in preventing: premature mortality from any cause, ischaemic heart disease, cerebrovascular disease, high blood pressure, colon and breast cancer, type 2 diabetes, metabolic syndrome, obesity, osteoporosis, sarcopenia, functional dependence and falls in the elderly, cognitive impairment, and anxiety and depression. This benefit is observed in both sexes and is greater the more volume or intensity of physical exercise.

Table 3.1. Main indications of physical exercise and their recommended grade

Indication	Recommended grade
Prevention of premature mortality from any cause	A
Prevention of ischemic heart disease and cardiovascular mortality	A
Preventing stroke in the brain	A
Preventing high blood pressure	A
Prevention of colon and breast cancer	A
Prevention of type 2 diabetes	A
Prevention of metabolic syndrome	A
Weight maintenance	A
Prevention of osteoporosis	A
Improvement of osteoarthritis of the knee and hip	C
Improving muscle strength and reducing sarcopenia	A
Reduced functional dependency and falls in the elderly	A
Reduction of cognitive impairment	A
Reduction of depression and anxiety	A

WHAT LEVEL OF PHYSICAL EXERCISE IS BENEFICIAL TO HEALTH?[53, 54]

Adapted from recent literature[55-63] and shown in the table below are the amounts of physical activity recommended by the American

College of Sports Medicine and the American Heart Association for improving fitness, reducing the risk of chronic disease and disability, and preventing overweight.

Table 3.2. Physical activity recommendations to improve fitness, reduce the risk of chronic illness and disability, and prevent overweight

Program to improve and maintain cardiorespiratory capacity and body composition	Program to improve and maintain strength and flexibility
• Moderate aerobic exercise, a minimum of 30 minutes, 5 days per week or intense exercise, a minimum of 20 minutes, 3 days per week **(A)** or a combination of both **(B)**. • This exercise should be in addition to low intensity physical activity during activities of daily living and moderate short-term physical activity (<10 minutes). • Periods of moderate physical activity lasting more than 10 minutes may be added together to complete the 30 minutes **(B)**. • In people over 65 or people aged 50 to 65 with chronic diseases or disabilities (e.g. arthritis), on a scale of 0 to 10, where 0 is sitting and 10 is the maximum effort, a score between 5 and 6 is considered moderate (the one that produces detectable tachycardia and tachypnea), and a score between 7 and 8 (the one that produces significant tachycardia and tachypnea) is considered intense. • More physical activity, not exceeding 5 hours of intense exercise per week, running more than 50 km or walking more than 75 km per week, produces more benefit **(A)**. It is prudent to limit the usual practice of intense exercise to 1 hour a day in people over 50 years of age.	• Strength: minimum of 2 non-consecutive days per week, with 8-10 exercises that develop most muscle groups (arms, shoulders, chest, abdomen, back, hips and legs) in each session and 10-15 repetitions of each exercise **(A)**. • Flexibility: at least 2 days per week for a minimum of 10 minutes, with 8-10 exercises including most muscle groups and tendons. Flexibility exercises should be done slowly and progressively, with stretching maintained for 10-30 seconds and 3-4 repetitions of each exercise **(B)**. • Balance: balance exercises (e.g. dancing) 3 times a week **(A)**.

How do you perform physical exercise from the point of view of health?

From a health point of view, the type of exercise, intensity, duration, frequency, progression rate and structure of the exercise session should be taken into account, depending on the initial level of fitness.

Intensity

Intensity is defined as the degree of effort required for an exercise. The main indicators of intensity are heart rate (HR) and oxygen consumption (VO_2). In people with an average fitness level and for intensities above 40% of VO_2max, there is a correlation between oxygen consumption and heart rate, so the latter parameter is usually used due to the ease of control through a heart rate monitor.

Beneficial effects on fitness occur with heart rates between 55 and 90% of maximum HR. The maximum HR can be estimated indirectly with various formulas, with little difference between them. Due to its simplicity of calculation, the following is usually used for adults:

Maximum (estimated) HR = 220 - age (in years)

The exercise prescription, based on the energy consumption of the activity, measures the calorific expenditure by means of the "metabolic equivalent" (MET), which is the amount of oxygen required to maintain the body's metabolic functions for 1 minute with the individual at rest and seated. 1 MET equals 3.5 mL of oxygen per kg per minute.

To calculate the energy expenditure of a given activity on the basis of METs, the equation recommended by the American College of Sports Medicine is used:

METs x 3.5 x weight in kg/200 = kcal/min

Low intensity activities are considered to be those that require less than 3.5 METs of energy expenditure, moderate intensity those that require 3.5 to 8 METs of energy expenditure (or 55-60% of the maximum CF), medium intensity those that require 8 to 12 METs (or 60-75% of the maximum CF) and high intensity those that require more than 12 METs (or 75-85% of the maximum CF).

Table 3.3. Calorie expenditure in metabolic equivalents of some sports activities

METs	Activity
1.5 - 2	• Walking at 1.5 km/h
2-3	• Walking at 3 km/h • Horseback riding on foot • Playing pool, bowling, boules or golf • Slow dancing
3-4	• Walking at 4 km/h • Cycling at 10 km/h • Jogging on horseback • Table tennis • Weightlifting • Slow canoeing or kayaking • Fast dancing
4-5	• Walking at 5 km/h • Cycling at 10 km/h • Very fast dancing • Tennis (doubles) • Slow swimming
5-6	• Walking at 6 km/h • Cycling at 16 km/h • Skating at 15 km/h • Digging in the garden
6-7	• Walking at 8 km/h • Individual tennis, squash • Skiing • Water skiing • Vigorous dancing (aerobics)
7-8	• Running at 8 km/h • Galloping on horseback • Roller hockey • Mountaineering • Alpine or cross-country skiing
8-9	• Running at 9 km/h • Cycling at 21 km/h • Fencing • Swimming at 35 m/min
>9	• Cycling at 23 km/h • Swimming at 40 m/min • Rugby (10 METs) • Basketball, football, judo, Basque pelota, competition rowing (12 METs)

Duration

The ideal duration of a session would be 20 to 60 minutes of continuous aerobic activity at the chosen intensity. After 20-30 minutes, the use of fat as a fuel for energy generation increases.

The duration of the exercise should be sufficient to increase the energy consumption by at least 287 kcal, therefore, with the recommended low intensities, it should last at least 30 minutes in the case of running and swimming, and 60 minutes in the case of cycling and aerobics.

Frequency

The recommended training frequency is 3 to 5 days per week. Training less than 2 days a week does not produce a significant increase in VO_2max. On the other hand, the additional health benefit from training over 5 days per week is minimal and the incidence of injuries may increase.

Rate of progression

The intensity of physical exercise should be increased gradually to make progress, starting with intensities between 50-55% of maximum HR.

Progression

- Beginning stage: comprises the first 4-6 weeks, progress should be gradual, starting with a mild intensity, for a short period of time and a few times a week.
- Improvement stage: the intensity, frequency and duration of the exercise are increased over 4 to 5 months with an increase in exercise every 2-3 weeks.
- Maintenance stage.

To maintain the beneficial effects, physical exercise must be practiced regularly. Cardiorespiratory condition decreases significantly after 2 weeks of stopping exercise and falls back to baseline after 10 weeks to 8 months. Reducing the frequency or duration of physical exercise over a 15-week period would not reduce VO_2max as long as the intensity of the training is maintained.

Structure of a session

An exercise session is usually structured in three parts:

- Warm-up phase: consists of a low intensity exercise (10-20 beats per minute above the resting HR) of 5-10 minutes duration.[64] Stretching before or after exercise does not appear to reduce the frequency of injury based on the review of studies published up to 2004, so there is no evidence to promote or reject this practice.[65-72] One study shows that static stretching for 5 min significantly increases range of motion for 30 minutes, although stiffness of the tendon muscle junction recovers at 5-10 min.[73]
- Effort phase: the type of exercise chosen is carried out with the desired intensity and duration.
- Recovery phase: progressive reduction of exercise over 5-10 minutes, rolling gently to promote venous return and the elimination of accumulated lactate and catabolites.

It is important to complete the training sessions with a good recovery. For this reason, it is necessary to schedule the training in a way that is balanced with the rest of the activities of daily life. For a good recovery, it is necessary to take into account the hygienic habits that favour a good physical condition:

- Avoid tobacco, alcohol and drugs.
- Proper diet.
- Enough nightly rest.
- Walk whenever possible (avoid the car, lift, etc.).
- Respect the biological rhythm (day-night).

In addition, other measures can be taken, either active (reducing the training load) or passive (hot water baths, massage, etc.).

PHYSICAL EXERCISE AND IMPROVING ATHLETIC PERFORMANCE[74]

Adaptation of the cardiovascular system to exercise

Physical exercise involves an increase in cellular respiration in the active muscles, so that the cardiovascular system must adapt, pumping the blood more efficiently to improve the supply of oxygen to the muscles.

The cardiovascular response to exercise is, in part, determined by the type of exercise practiced. Sports are often classified as predominantly dynamic or static.

Dynamic exercise is characterised by a predominantly aerobic metabolic pathway, a type of isotonic muscle contraction and a long duration. It is typical of endurance sports (e.g. running, cycling, team sports, etc.). Static exercise, on the other hand, is characterised by a predominantly anaerobic metabolic pathway, a type of isometric muscle contraction and a shorter duration. It is typical of strength sports (e.g. weightlifting, etc.). Many sports disciplines share both components.

The increased use of oxygen by active muscles is caused by several mechanisms: increased oxygen extraction from the blood by muscle cells, vasodilatation in the areas involved, increased cardiac output, increased pulmonary blood flow and increased pulmonary ventilation.

Maximum oxygen consumption (VO_2max) is an individual aerobic power parameter. It is defined as the maximum amount of oxygen that a person can capture, transport and use in the different organs responsible: lungs, cardiovascular system and muscles. It is measured during a stress test by analysing the exhaled gases during an exercise of increasing intensity.

Normal values for a 20-year-old are 37-48 mL of oxygen/kg/min. Elite male athletes can reach values of 70-80 mL/kg/min, as training improves the muscle's ability to use oxygen efficiently and can keep anaerobic metabolism to a minimum at a given level of effort. VO_2max decreases by 7% with each decade of life after age 30.

The factors defining VO_2 are expressed by the Fick equation:

$$\mathbf{VO_2 = Q\text{-}C(a\text{-}v)O_2 = HR\text{-}Vs\text{-}C(a\text{-}v)O_2}$$

(VO_2: oxygen consumption; Q: cardiac output; HR: heart rate; Vs: systolic ejection volume; $C(a\text{-}v)O_2$: arteriovenous oxygen difference)

In Mitchell's classification, sports are classified according to the amount of oxygen consumed (dynamic component) and the percentage of maximum force used in their performance (static component).

Table 3.4. Classification of sports according to oxygen consumption (adapted from Mitchell)

Static component			
High (>50% maximum voluntary contraction)	Bobsleigh, gymnastics, throwing, martial arts, sailing, climbing, water skiing, weightlifting, windsurfing	Bodybuilding, alpine skiing, skateboarding, snowboarding, wrestling	Boxing, canoeing, kayaking, cycling, decathlon, rowing, speed skating, triathlon
Moderate (20-50% maximum voluntary contraction)	Archery, motorsport and motorcycle racing, diving, horse riding	Football, jumping, figure skating, rugby, speed racing, synchronised swimming, surfing, rodeo	Basketball, ice hockey, cross-country skiing (skating technique), swimming, handball, lacrosse
Low (<20% maximum voluntary contraction)	Bowling, billiards, cricket, curling, golf, olympic shooting	Baseball, fencing, table tennis, volleyball	Badminton, cross-country skiing (classic technique), field hockey, orienteering, race walking, squash, soccer, tennis, long distance running
Dynamic component	Low (<40% maximum O_2 consumption)	Moderate (40-70% maximum O_2 consumption)	High (>70% maximum O_2 consumption)

Cardiovascular adaptation to dynamic exercise

To meet the metabolic demands of skeletal muscle during exercise, two major adjustments in blood flow occur: first cardiac output increases and, second, blood flow to inactive organs and tissues is redistributed to active skeletal muscles.

Increased cardiac output

This adjustment occurs as a result of the increased heart rate and systolic ejection volume. The systolic volume increases to 40% of VO_2max, from about 80 mL/beat to about 120 mL/beat. The heart rate increases from about 70 beats per minute to about 200 beats per minute. In this way, the cardiac output can go from approximately 5 L/min to about 25-30 L/min.

All this leads to an increase in the amount of oxygen passing from the blood through the capillary bed (arteriovenous difference), from 4 mL of oxygen per 100 mL of blood at rest, to 18 mL of oxygen per 100 mL of blood during high-intensity aerobic exercise.

Redistribution of blood flow

At rest, the muscles receive about 20% of total blood flow, but during exercise this flow can increase to 80-85% while reducing blood flow to inactive visceral and skeletal muscle tissues.

The redistribution of blood occurs through various mechanisms. During exercise a generalised vasodilatation occurs due to the accumulation of vasodilator metabolites. This leads to a decrease in peripheral resistance, which activates the baroreceptors causing an increase in sympathetic activity. This increase in sympathetic activity produces vasoconstriction in the visceral organs, while vasodilatation predominates in the blood vessels of the muscles and coronary circulation, thanks to local vasodilator metabolites. At the cutaneous level, first vasoconstriction is produced by sympathetic activity and then vasodilatation is produced to dissipate the heat produced by muscular activity, increasing the cutaneous blood flow.

Haemodynamic adaptation

Blood flow to the tissues depends on the relationship between blood pressure and the resistance provided by the blood vessels. Blood flow during exercise increases due to increased blood pressure and decreased vessel resistance in the systemic circulation of active skeletal muscles.

Cardiovascular adaptation to static exercise

The cardiovascular changes during static exercise are different. The muscle contraction that occurs in static exercise compresses the blood vessels of the muscles that are contracting, leading to a reduction in blood flow to the muscle. Therefore, peripheral vascular endurance is not reduced as in dynamic exercise, but may even increase, especially if large muscle groups are involved in exercise.

Therefore, by not decreasing peripheral resistance, the increase in heart rate and cardiac output are lower, unlike the increase in systolic, diastolic and mean blood pressure which are higher compared to dynamic exercise.

Because blood pressure is an important determinant of post-load, the left ventricular wall tension, and therefore the cardiac workload, is significantly higher during static exercise compared to the cardiac workload achieved during dynamic exercise.

Just as dynamic exercise may result in a volume overload to the heart, by increasing the pumping function in parallel with increased venous return and increased oxygen demand from the active muscles, static exercise can lead to a pressure overload to the left ventricle.

Physiological effects of training (chronic exercise) on the cardiovascular system

Chronic exercise (training) produces different relevant adaptations in the cardiovascular system.

At rest, there is an increase in heart size, ventricular telediastolic volume and myocardial thickness. There is a decrease in resting heart rate due to the reduction in the intrinsic frequency of the sinoatrial node, related to increased parasympathetic activity and reduced sensitivity of the myocardium to circulating catecholamines, and a predominance of vagal secondary to reduced adrenergic activity.

There is also an increase in the systolic ejection volume. Each heartbeat pumps more blood because of the increased ventricular cavity and increased myocardial contractility.

Another change observed is an increase in total blood volume due to increased plasma volume and haemoglobin, although a slight decrease in haematocrit can be observed due to the fact that plasma volume increases proportionally more than haemoglobin. Systolic blood pressure decreases, especially in hypertension, and peripheral vascular resistance decreases. And finally, capillary density increases, going from 4.4 to 5.9 capillaries per muscle cell.

Compared to untrained people, during submaximal exercise the heart rate decreases due to the lower sympathetic tone and the systolic volume increases due to the increase in the ventricular cavity and myocardial contractility. In addition, cardiac output stabilises or decreases slightly. Muscle blood flow decreases because, for a certain workload, it is lower in trained subjects due, among other reasons, to a greater capacity for oxygen extraction by trained muscles (greater arteriovenous oxygen difference).

Myocardial oxygen consumption (HR x systolic TA) is reduced for any intensity of exercise due to a decrease in heart rate with or without a modest reduction in blood pressure. In healthy subjects, the product can decrease significantly without any loss of efficiency for a specific workload.

During maximum exercise, as in the submaximal, the maximum heart rate remains stable or decreases slightly.

In most cases, the systolic volume reaches its plateau at 40-60% of maximum VO_2. This applies to both trained and untrained people of both genders. The systolic volume of untrained men can approach 100-120 mL/heartbeat while, for trained men, this value is 150-170 mL/heartbeat and can reach 200 mL/heartbeat in highly trained athletes. Women's values are lower than men's. The maximum systolic volume for untrained women is usually between 80 mL/heartbeat, and for trained women between 100 mL/heartbeat.

Arteriovenous oxygen difference improves due to the increased diffusion gradient for oxygen between the capillaries and the active musculoskeletal cells, the increase in the total myoglobin (protein that binds oxygen in skeletal muscle) contained in the trained skeletal muscles, and the increase in capillary density.

After exercise (recovery), training decreases the recovery heart rate: the heart recovers more quickly.

Benefits of aerobic exercise: summary

Respiratory and cardiocirculatory capacity improves. Physical exercise increases the volume of air mobilised per minute, as well as the volume of the heart chambers and the thickness of their walls, and increases the number of capillaries through which blood circulates. This enlargement of the heart is a normal adaptation to chronic resistance training, and is not pathological.

Metabolic capacity of energy production improves at muscle level and the storage and mobilisation capacity of energy reserves improves (increases glycogen reserves).

Musculoskeletal benefits are:

- Muscle mass is increased or maintained.
- Muscle capillarisation increases.
- Mitochondrial density of the muscle and the activity of its aerobic enzymes increase, improving energy production. Mitochondria are the cellular organelles where energy is produced, and enzymes are the substances that facilitate the production of energy.
- Structure and function of ligaments and tendons improves.
- Joint movement range increases or is maintained.

SPORTS TRAINING

Training should cover three main aspects:

Technical preparation: the aim is to achieve maximum mastery of the techniques required to perform the movement in the best possible way. An important aspect of the technical preparation is that it allows a great economy of forces: it avoids contracting muscles that are not directly involved in the production of movement (unnecessary contractions of the muscles of the face or hand, unnecessary vertical or lateral movements of the body). If a muscle is stretched as much as possible beforehand, it will contract further. If the muscle fibres used are changed, fatigue comes later (change of side while cramponing, positional changes when skiing, alternating grips in climbing holds, etc.). Technical sessions should be done immediately after the warm-up period. Do not try to assimilate a technique if you are tired. It is better to work on technique in segments (walking with crampons and without ice axes, skiing without poles, etc.). Technique is maintained throughout life, unlike resistance and strength.

Tactical preparation: seek to improve performance by looking for the most appropriate use of methods, prioritising decision-making on the basis of determining factors (physical, technical, psychological, sociological, knowledge of the environment and of the material, etc.)

Physical preparation: its goal is to improve an individual's physical capacities, both the basic conditional capacities (stamina, strength, speed and flexibility) and those specific to each sport.

BASIC PHYSICAL QUALITIES

Resistance (stamina)

Is the psychophysical ability to sustain an effort effectively for as long as possible without diminishing performance. It is the most important quality for people who practice mountain sports. Mountaineering is a great endurance sport in which stamina prevails.

Inside each muscle cell, the mitochondrion is the place where glucose and fatty acids are oxidised to produce ATP (energy), which allows the muscle to act. Glucose and fatty acids are the fuels and oxygen is the oxidiser, that is, the thing that causes the combustion of fuels. To get more oxygen, you have to develop your cardiovascular system. Our best fuel is glucose, which is stored in muscle and liver as glycogen. Muscle glycogen deposits are low (15-45 g per kg of muscle), which is why liver glycogen is used. Moreover, each gram of glycogen is accompanied by 2.7 g of water. Lipids are a more abundant source of energy, but they are not as effective as glycogen. As long as there are glycogen deposits, these are used first and foremost; in addition, the lipidic fuel consumes more oxygen.

Cardiorespiratory endurance is the ability to efficiently carry oxygen. Resistance fundamentally works on the cardiovascular and respiratory apparatus, which is the oxygen transport system. The work is done by many muscles and in a sufficiently intense way to require a sufficient amount of oxygen to increase the functioning of these systems.

Aerobic resistance: when the intensity is not very high, the transport system provides enough oxygen to maintain this intensity for more than 30 minutes, thanks to the energy produced by the degradation of fatty acids and glycogen stored in the liver.

Anaerobic resistance: when the intensity is very high, the transport system is not able to provide enough oxygen for aerobic glycolysis to work and the energy is produced through the degradation of the glycogen stored in the muscle itself, producing lactic acid. This system produces less energy than the aerobic and accumulates lactic acid, for these reasons the intensity of the effort cannot be maintained for more than 3 minutes.

At low intensities the metabolism of fats is stimulated, and at high intensities the metabolism of glycogen is stimulated.

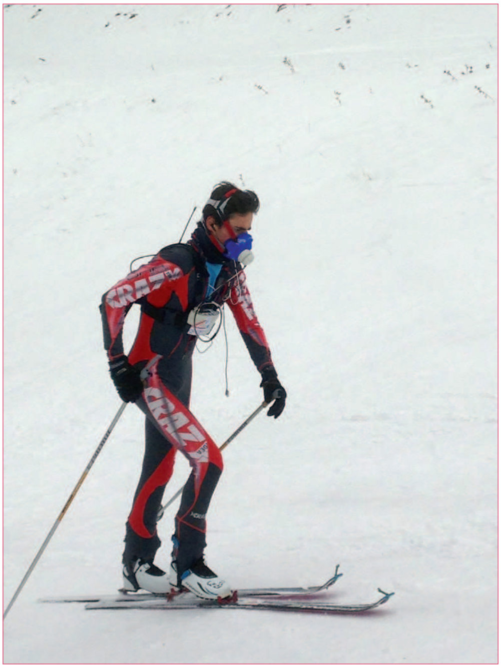


Figure 3.1. Ski mountaineering stress test.

Regarding resistance, we have to take into account two qualities:

- Aerobic power: is the maximum value of oxygen consumption that can be achieved in a given time and is evaluated by maximum VO_2: This is the measure of the maximum oxygen consumption during the effort; the more oxygen is consumed, the more energy is produced and the higher the speed of travel over long distances.
- Aerobic capacity: is the capacity to prolong high oxygen consumption for the maximum possible time and is evaluated by the anaerobic threshold. When doing physical exercise, an important first accumulation of lactic acid of around 2 ± 0.5 mmol/L (aerobic threshold) is produced, which corresponds to the maximum metabolic energy efficiency, with a balance between the used and resynthesized ATP, where a communication can be perfectly maintained and where there is muscular, cardiac and respiratory comfort. The energy provided by aerobic metabolism is sufficient. Then

there is a second, more intense accumulation of lactic acid that cannot be eliminated aerobically, at around 4 ± 0.5 mmol/L, which limits exercise duration to this intensity (anaerobic threshold) corresponding to the intensity of effort where the muscle energy requirement exceeds the energy provided by aerobic metabolism, and the anaerobic pathway (anaerobic glycolysis) begins to be claimed to obtain more energy at the expense of producing lactic acid, which generates the subsequent metabolic acidosis.

In a stress test the metabolism involved is observed according to the respiratory quotient (RER) which is determined by gas analysis (O_2/CO_2 consumption). If the RER is 0.7, priority is given to the use of fats (aerobic threshold). When the RER = 1, the use of glucose as an energy fuel (anaerobic threshold) prevails.

We can currently determine the effort intensity heart rate corresponding to these "physiological states" and from here we can plan the different types of training: extensive aerobic, intensive aerobic, extensive anaerobic and intensive anaerobic.

There are different systems for increasing endurance; the differences are determined by the duration of the activity, the rest time and the number of repetitions and sets.

To improve aerobic capacity, work should be done at an intensity of at least 60-70% of maximum heart rate. The desirable frequency is 4-6 sessions per week.

There are several methods of aerobic endurance training, the most commonly used are:

- Continuous harmonic system
  - Low intensity: the work intensity is low (less than 70% of the maximum HR), and the effort duration is high (1-3 hours). This improves long-lasting endurance and promotes fat metabolism and aerobic glycolysis; for example, a continuous race consists of running long distances of 5-30 km (20 to 120 minutes) at a rate that improves cardiocirculatory fitness.
  - High intensity: the work intensity is higher (70-90% of the maximum HR). It promotes glycogen metabolism rather than fat metabolism.
- Continuous variable system: changes in intensity are made (Fartlek, which means "speed play" in Swedish, natural routes with slopes, etc.). Fartlek consists of running alternating rhythm changes depending on the characteristics of the terrain, for distances and times ranging between 5-20 km and 15-45 minutes. A varied terrain with different types of slopes should be chosen.
- Interval system: alternates phases of effort with short phases of incomplete recovery. It improves maximum aerobic power (VO_2 maximum), increases the anaerobic threshold and anaerobic capacity, and improves the ability to withstand high lactate levels. These systems allow the total distance to be run faster than if it were run continuously. It can be of medium or high intensity.
- Repeat system (high intensity sets): this differs from the previous one in that the recoveries are complete. It improves maximum strength and strength-resistance at high intensity and speed.

The continuous systems and the medium or low intensity interval system are aimed at improving basic physical form, and the high intensity interval system at achieving a competition rhythm.

It is dangerous to start anaerobic training if a good aerobic base has not been achieved with low intensity and long duration training.

Figure 3.2. Ski mountaineering.

Empirically, it can be considered that 75-80% of training should be done at a talk-test pace.

Sports that improve endurance are: athletics (cross-country, middle and long distance), cycling (MTB), skiing (cross-country and mountain), team sports, water sports or tennis.

It is important to train in the mountains to adapt to the climatic conditions and altitude of the environment (Fig. 3.2).

How to run in the mountains

When climbing uphill, the body must be tilted forward and the step shortened. Hands rest on legs to accompany movement and feet are placed slightly open (like a duck) to improve grip, especially on grassy ground. On slopes exceeding 15-20%, it can be more profitable to walk than to run, because you gain in amplitude what you lose in frequency, and you will also reach the top in better condition to face the flat terrain or the descent.

Going downhill, instinct makes you run with great strides, the body leant back to be able to stop and with the heels receiving the impact, all of which can produce considerable back pain. It would be better to tilt the body forward, perpendicular to the slope, shorten the stride using forefoot reception and spread the arms to maintain better balance. Cushioning is achieved by bending the knees. On slopes of more than 10%, it would be better to look for lateral supports. In order to avoid sprains, the contact time of the foot with the ground should be very short as if running on burning coals, especially if the ground is unstable. In any case, it is necessary to observe what is on the ground some paces ahead in order to choose where to place the foot and to avoid stumbling with unpleasant consequences.

Figure 3.3. Physical preparation.

In terms of endurance, to develop and maintain an adequate physical form in practice, 3-5 continuous running sessions of 30-60 minutes per week, at a rate of 70-80% of maximum HR are sufficient, trying to incorporate 30-60 minutes per week at a rate of 80-88% of maximum HR. This higher pace should be done at intervals of 10-15 minutes, in one or two sessions, and always after having run at least 15 minutes at the beginning and at least 10 minutes at the end.

Strength

Is the neuromuscular capacity to overcome external resistance or strong opposition to movement.

Endurance sports are worked on in an aerobic way and the strength developed is less than 20% of maximum. To avoid loss of muscle mass, we must do weight training exercises and mainly strength-resistance. Aerobic activities have little influence on upper body muscle strength-resistance.

There are different kinds of strength:

- Maximum force: is the highest force that a muscle group can execute against maximum opposition (weightlifting). It improves by doing few repetitions with as high a load as possible; the maximum weight is the weight that can be lifted in that exercise for a single repetition. In climbing, maximum strength is required on athletic routes, overhangs, etc. There are two fundamental types of maximum stresses: static (holding with one or two arms) and dynamic (lifting up all our weight on one or two arms).
- Hypertrophic force: this is a type of maximum force but the aim is to increase muscle mass. For this purpose, strength exercises are performed at an intensity of 70-80% with 10 sets of 8-12 repetitions.
- Speed-strength: has effect over a very short period of time (javelin throwing). Improves with

medium loads (60-75% of maximum load) and a moderate number of repetitions (6-10).

- Endurance: the ability to maintain repeated muscle contractions as often as possible, or a fixed contraction for as long as possible. Improves with low and medium loads (30-60% of maximum) and many repetitions (15-40). Recovery is incomplete (1-3 minutes). The most commonly used means are the body itself and weights. Strength-resistance exercises consist of isolated contractions of muscle groups that seek to mobilise a load or overcome an external resistance that opposes movement.
  They can be:
  - Dynamic: the contractions modify the length of the muscle.
    - Isotonic: they keep the tone constant with a variable contraction speeds, producing muscle shortening (concentric) or developing tension while allowing the muscle to stretch (eccentric).
    - Isokinetics: keeps a constant contraction rate and varies the pitch.
  - Static (isometric): the contractions do not modify the length of the muscle. Isometric contractions limit the blood supply to the muscle. Isometric working techniques only improve the force at the angle that is being worked.

To develop and maintain strength, 2-3 sessions per week are recommended, with 8-10 exercises in each session that develop most muscle groups (arms, shoulders, chest, abdomen, back, hips and legs) and 10-15 repetitions of each exercise.

Flexibility

Is the ability to move joints throughout their full range of motion. Muscle elasticity is the ability of a muscle to stretch.

Flexibility has unmodifiable bone limits that depend on heredity, ligament limits and joint capsules that can be modified by training, and muscle limits (elasticity) that can also be modified.

The method of proprioceptive neuromuscular facilitation consists of passive stretching and, in this position, isometric contraction of the stretched muscle group for 6 seconds followed by muscle relaxation for 5-10 seconds, repeated until an insurmountable stretching limit is reached.

To develop and maintain flexibility, 2-3 weekly sessions are recommended, with 8-10 exercises that include most muscle groups and tendons. Flexibility exercises should be done slowly and progressively, maintaining stretching for 20-30 seconds and performing 5-10 repetitions for each muscle group.

Speed

Is the ability to perform a movement as quickly as possible.

A distinction must be made between reaction speed, muscle contraction speed and movement speed.

Other qualities

- Coordination: is the ability to use the properties of the nervous and muscular systems together without interfering with each other.
- Balance: is the power to adopt a position against the force of gravity.
- Relaxation: is the lowest state of tension of a muscle.
- Rusticity: is the ease of adaptation to variations in environment and circumstances, it is very characteristic of mountain sports.

Table 3.5. Rest time between sessions

Trained quality	Rest between sessions
Speed	48-72 hours
Force-Speed	24-48 hours
Strength-resistance	48 hours
Strong resistance (80-88% of maximum HR)	48-72 hours
Soft resistance (70-80% of maximum CF)	12-24 hours
Agility-coordination	6 hours
Flexibility	6 hours

It is inadvisable to work on technique when in a state of fatigue.

In life-or-death situations, five personality traits have been identified that enhance survivability:

- The will to survive.
- Adaptability and the ability to improvise.
- Optimism and the conviction that this is only a temporary situation.
- Ability to tolerate grotesque situations calmly and rationally.
- Sense of humour.

Fundamental principles of sports training

Overload principles

- Principle of optimum Recovery/Load Ratio (RLR): in order to achieve supercompensation, the choice of the appropriate load (intensity and volume) and the recovery phase is essential.
- Principle of progressive load increase: performance improvement is related to the effort carried out during training that causes the body to undergo the fatigue and overcompensation phases; from this we can deduce the need to progressively increase the loads, since the body adapts to the demands to which it is subjected. If the loads are not increased there is no improvement, simply maintenance and then regression. The methodological order for increasing load is to increase training frequency, increase volume (duration) and finally increase intensity.
- Principle of discontinuous load increase: continuous load increase can lead to overtraining. To avoid this, a phase of unloading must be introduced into sports planning to allow the body to adapt to the relative recovery. This creates a good readiness for future performance increases. After a high level of effort, intensity must be reduced. This wave method is applied to both weekly work and within the physical preparation cycle.
- Principle of load versatility: training monotony, which can lead to a decrease in performance, is avoided by varying the way loads are applied.

Principles of cyclical periodisation

- Principle of repetition and continuity: an isolated stimulus is not sufficient to produce supercompensation, it is necessary to repeat loads in the same direction with precise frequency.
- Beginning training periodisation: the training load cannot be kept at the limit of the athlete's abilities all year round, it is necessary to make periodic modifications in the training and recovery sessions. Depending on their length, training cycles can be small or microcycles, medium or mesocycles, and large or long training periods.

Principles of specialisation

- Principle of adaptation to age and individuality of the athlete: training must be adapted to each athlete.
- Principle of wholeness: training must develop all the physical and psychological qualities of an individual. Specialisation is developed after a good foundation in total training.
- Principle of continuity of the training process: training must be continued throughout the individual's sporting life. It must be based on previous training and must provide for appropriate recovery intervals to improve capacity.

Scheduling physical preparation in mountain sports

Mountain sports in general are characterised by their long duration, they are of general resistance with an endurance component.

When scheduling a training session, the general and specific objectives of the program should be defined and the annual cycle should be divided into three periods:

- Preparatory.
  - General preparation subperiod with increased workload.
  - Specific preparation subperiod with increased work intensity.
- Competitive or high performance (in non-competitive activities).
- Transitory.

- Recovery subperiod.
- Active rest subperiod.

RISKS OF EXERCISE

The practice of physical exercise entails, fundamentally, two types of risk: a risk of injuries to the locomotor system and cardiovascular risk.

Locomotor system injuries

There are 0.19-1.3 injuries per 1,000 hours of physical exercise. Following the minimum exercise recommendations outlined above, one injury per person occurs every 4 years. Risk factors for injury include sedentariness, age, previous injury, amenorrhea, and smoking. The risk of injury increases considerably after 64 km of running per week.

Cardiovascular risk[75]

Although physical exercise is useful in reducing the risk of cardiovascular disease, it also carries some cardiovascular risk in itself. The most relevant complications are sudden death and acute myocardial infarction, usually in people with underlying structural heart disease.

In younger people, the risk is almost always related to the presence of birth defects. Most deaths are caused by sudden onset arrhythmias, especially tachycardia or ventricular fibrillation. They may occur because of interaction between the underlying heart disease and the trigger of the increased exertion, along with other possible associated triggers such as emotional stress, hemodynamic changes, altered parasympathetic tone, and myocardial ischemia.

The risk varies according to the type of sport, but is generally low. In marathon running there is 1 sudden death every 215,000 hours, while in the non-competitive race the incidence is 1/396,000 hours and in Nordic skiing 1/607,000 hours. In the largest study of 10.9 million runners, 59 cases of sudden death were observed with an incidence of 0.54 deaths per 100,000 runners. It is 1.01 per 100,000 in marathons and 0.27 per 100,000 in half marathons. In men it was 0.90 per 100,000 and in women 0.16 per 100,000. The main cause was hypertrophic cardiomyopathy followed by ischemic heart disease.[28]

In people over the age of 40, the risk is largely related to atherosclerotic disease. In both groups, the risk of the underlying pathology manifesting itself clinically increases with intense exercise, especially in sedentary people. For this reason, exercise programs are initiated with a low intensity, which can be controlled with subjective methods such as the talk-test. The overall incidence is 18 cardiovascular events per million person-hours in the least active group and only 5 events in the most active group.

Finally, in several case and control studies, with samples of less than 300 athletes, with an average age of 40-50 years and mostly men (70%), the risk of suffering atrial fibrillation increases between 2 and 10 times.[76] The increased risk appears to be focused on athletes who at age 30 practised high-intensity exercise for more than 5 hours a week; while walking or cycling at age 60 reduced the risk by 60. The underlying mechanism behind this association is unclear, although a greater auricular size was observed in athletes than in the controls.

Fatigue

Fatigue is a marked decrease in performance that, in addition to involving an increase in the effort required to voluntarily perform work, results in an occasional or temporary inability to perform said work (Table 3.6).

Figure 3.4. Fatigue during an Arctic ski tour.

Table 3.6. Kinds of fatigue

Central	Determined by the central nervous system, it affects coordination abilities.
Peripheral	Local muscle, caused by a decrease in muscle ATP concentration.
	General organic, affects different organs and systems.

From a physiopathological point of view it can be:

- Physiological: set of mechanisms of physiological response to physical effort, reversible with rest.
- Pathological: it occurs when the mechanisms of adaptation have been overcome and this triggers a series of general homeostatic alterations.

Depending on clinical aspects it can be:

- Acute: physiological process that occurs during physical activity, is reversible with rest, and promotes the processes of overcompensation and adaptation.
- Overacute or exhaustion.
- Chronic or overtraining. Overtraining has different characteristics depending on the predominant nervous system. In 'explosive' sports, the sympathetic one predominates, and in endurance sports, the parasympathetic one (Table 3.7).

The causes of fatigue in sport are multiple: decreased energy reserves, dehydration, decreased blood flow and oxygen in the muscles, accumulation of intermediate and terminal metabolic substances (lactic acid, urea, etc.), inhibition of enzymatic activity, electrolyte displacement or hormonal decrease due to intense and continuous effort.

The symptoms of fatigue are diverse:

- Feeling of exhaustion even in everyday activities that normally would not present any problems.
- Apathy in the face of external stimuli, demotivation.
- Sleep disorders.
- Decreased appetite.
- Weight loss greater than 3%.
- Dizziness, hot flushes, nausea or headaches.
- Menstrual disorders.
- Increased muscle and tendon pain.
- Decreased performance.
- Decreased strength and reflexes.
- Elevation of the morning heart rate above 10%.
- Decrease in the testosterone/cortisol ratio by more than 30%.

Table 3.7. Sympathetic and parasympathetic activity

Sympathetic	Parasympathetic
• Increased basal heart rate. • Weight loss. • Decreased appetite. • Emotional instability. • Night sweating. • Increase in basal metabolism. • Abnormalities in the ECG. • Increased blood pressure at rest. • Delayed recovery. • Decrease in maximum lactate levels. • Increased incidence of infections.	• Decreased basal heart rate and blood pressure. • Decreased heart rate during exercise. • Decrease in plasma lactate during maximum and submaximal exercise (lactate paradox). • Rapid pulse recovery. • Anaemia. • Digestive problems. • Low reactivity. • Hypoglycaemia.

Intense muscle exercise can lead to fatigue due to:

- Dehydration, so adequate hydration is recommended **(A)**.
- Energy consumption higher than its contribution (energy debt).

Fatigue can produce:

- Hypoglycaemia.
- Dehydration and ionic disorders.
- Hypothermia during rest.
- Hyperthermia during exercise.
- Accumulation of toxins.

The most common symptoms are fatigue and hypothermia, but there may also be signs of dehydration.

The loss of water causes dehydration which results in a decrease in sporting performance, with a reduction in working capacity, fatigue resistance, maximum power, reaction speed and degree of coordination. Under normal conditions, the thirst centre is not activated until the volume of body water decreases to values of 1-2% of body weight, therefore thirst is not the best indicator for assessing dehydration; urine colour may be more useful.

Prevention is based on:

- Proper diet with carbohydrates,
- Lightly salted drinks without waiting for thirst, since the most frequent dehydration in the mountains is mixed, that is, the loss of water and salts, and this type of dehydration does not produce a sensation of thirst. Also, a chronic hydration deficit (remaining 4 hours or more without rehydration) decreases performance, regardless of ambient temperature.
- Provide rest breaks, without them being too long to avoid energy-consuming cooling.
- Avoid hyperthermia, which can occur with exertion, and hypothermia, which can occur with rest.
- Avoid lack of sleep.

Treatment is based on rest and the supply of energy substrates, water and electrolytes **(A).**

Lack of sleep

The average time an adult needs to sleep each night is about 7-8 hours.[77-80] Losing 4 hours of sleep reduces the immune activity of cells that fight cancer and viruses by 28%.

A 2-4 hour nap has a similar effect on mental performance to the consumption of 150-300 mg of caffeine (1 cup of coffee = 100 mg of caffeine).

When it is not possible to sleep the amount of hours needed (adventure raid), a strategy would be to combine 2 hours of sleep with 200 mg of caffeine, this dose is effective after one hour and its effects persist for 8 hours.

Section II

ENVIRONMENT-RELATED PROBLEMS

CHAPTER 4
Temperature regulation

CHAPTER 5
Hypothermia

CHAPTER 6
Frostbite and other cold-related illnesses

CHAPTER 7
Heat, dryness and humidity

CHAPTER 8
Solar radiation

CHAPTER 9
Lightning, fog and wind

CHAPTER 10
Altitude

CHAPTER 11
Animal bites and stings

CHAPTER 12
Poisoning by plants

CHAPTER 13
Mushroom poisoning

4 TEMPERATURE REGULATION

The core temperature of the human body is 37 °C (36.5-37.2 °C). If you are naked you can only maintain core temperature when the ambient temperature is above 28-30 °C. Below this figure, we rely on clothing and shelter to insulate ourselves from the environment and reduce heat loss. Hypothermia can already pose a risk when the ambient temperature is below 15.5 °C.

At rest, the human body produces 40-60 kcal of heat per m^2 of body surface. Movement and shivering can increase heat production by 2 to 5 times.

MECHANISMS OF HEAT LOSS

Heat can be lost through various mechanisms:

- **Radiation.** Heat is lost by direct transfer to the environment. Heat loss by radiation depends on the surface area exposed and the temperature difference between the body and the environment. The colder the environment and the more body surface area exposed, the more heat is lost. In a dry environment, radiation is the most important cause of heat loss (55-65% of heat loss). A dressed person usually loses 30% of their heat through the head and neck, and this loss can be as much as 70%. If you wear a bathing suit, the heat loss occurs more proportionally over the entire skin, with only 10% being lost through the head. Clothes make sure heat doesn't get lost so quickly. Wool is a good insulator and retains its properties even when wet, while cotton loses its properties when wet. In cold weather we should put on 3 or 4 layers of dry clothes. In an emergency, it may be helpful to wrap yourself in 14-15 layers of newsprint.
- **Convection.** The air in contact with the skin warms up to skin temperature; when the warm air moves, cold air arrives in its place and must be reheated, causing the body to lose heat. The greatest convection heat losses occur when the air is moving (wind), as it replaces hot air with cold air. It is responsible for 10% of heat loss. When the air temperature is higher than the body temperature, the body gains heat. The amount of heat subtracted by the wind increases proportionally to the square of the speed and not in direct proportion to it (for example, wind at 12 km/h extracts four times as much heat as other wind at 6 km/h, and not twice as much). To define this robbing of heat by the wind, Antarctic explorer Paul Siple coined the word windchill. Heat loss by convection can be reduced by using an outer layer that does not allow the wind to pass through (windstopper, Gore-Tex, sympatex and similar fibres) (Table 4.1).

At −30 °C, the parts of the body exposed to the wind can freeze in one minute, and at −60 °C, in 30 seconds. According to Danielsson, whatever the wind speed, the risk of freezing is small if the ambient temperature is above −10 °C, and high if it is below −25 °C.[82]

Wind speed can be estimated by a series of indications according to the Beaufort scale of wind force. To go from m/sec to km/h we multiply by 3.6 (Tables 4.2 and 4.3).

- **Conduction.** Body heat is lost through contact with something cold such as water, metal, etc. Immersion in cold water can increase conductive heat loss by 25-70 times compared to air, and contact with steel even more so. Generally, conductive heat loss

Table 4.1. Equivalent wind chill temperature (Air Force of Argentina and National Weather Service) (*)

0 km/h	8 km/h	16 km/h	24 km/h	32 km/h	40 km/h	48 km/h	56 km/h	64 km/h
10 ºC	7.5 ºC	5 ºC	2.5 ºC	0 ºC	0 ºC	−2.5 ºC	−2.5 ºC	−2.5 ºC
5 ºC	2.5 ºC	−2.5 ºC	−5 ºC	−7.5 ºC	−7.5 ºC	−10 ºC	−10 ºC	−10 ºC
0 ºC	−2.5 ºC	−7.5 ºC	−10 ºC	−12.5 ºC	−15 ºC	−17.5 ºC	−17.5 ºC	−20 ºC
−5 ºC	−7.5 ºC	−12.5 ºC	−17.5 ºC	−22.5 ºC	−22.5 ºC	25 ºC	−25 ºC	−27.5 ºC
−10 ºC	−12.5 ºC	−17.5 ºC	−25 ºC	−25 ºC	−30 ºC	−32.5 ºC	−32.5 ºC	−35 ºC
−15 ºC	−17.5 ºC	−25 ºC	−32.5 ºC	−35 ºC	−37.5 ºC	−40 ºC	−42.5 ºC	−42.5 ºC
−20 ºC	−22.5 ºC	−32.5 ºC	−37.5 ºC	−42.5 ºC	−45 ºC	−47.5 ºC	−50 ºC	−50 ºC
−25 ºC	−27.5 ºC	−37.5 ºC	−45 ºC	−50 ºC	−52.5 ºC	−55 ºC	−57.5 ºC	−60 ºC
−30 ºC	−32.5 ºC	−45 ºC	−52.5 ºC	−57.5 ºC	−60 ºC	−62.5 ºC	−65 ºC	−65 ºC
−35 ºC	−37.5 ºC	−50 ºC	−57.5 ºC	−65 ºC	−67.5 ºC	−72.5 ºC	−72.5 ºC	−75 ºC
−40 ºC	−45 ºC	−57.5 ºC	−65 ºC	−70 ºC	−75 ºC	−77.5 ºC	−80 ºC	−82.5 ºC
−45 ºC	−50 ºC	−62.5 ºC	−72.5 ºC	−77.5 ºC	−82.5 ºC	−85 ºC	−87.5 ºC	−90 ºC
−50 ºC	−55 ºC	−67.5 ºC	−77.5 ºC	−85 ºC	−90 ºC	−95 ºC	−95 ºC	−97.5 ºC

(*)Winds with speeds above 64 km/h only produce a small additional effect.

accounts for 2% of the total loss, but with wet clothing this loss can be multiplied by five. Sleeping on the floor without adequate insulation increases heat loss through conduction. Captive air is the best insulator against the cold, which is why foam mats offer greater insulation than air mattresses, as the latter allow air to circulate freely.

- **Evaporation.** Is the transformation of water from its liquid form to its gaseous form (vapour). When water evaporates, it takes heat with it. Evaporation is responsible for 22% of heat loss. Evaporation of water from the body can occur through the exhaled air - which contains water - or through the skin (perspiration or sweating). Sweating can be

Table 4.2. Beaufort scale of wind force

Beaufort number	Wind speed (km/h)	Ground effects
0	0 a 1	Calm and settled; smoke rises vertically
1	2 a 5	Smoke indicates wind direction
2	6 a 11	Tree leaves rustle; mills begin to turn
3	12 a 19	The leaves in constant motion; light flags fluttering.
4	20 a 28	Dust and papers are raised, branches moved
5	29 a 38	Small trees begin to sway, wavelets on lake surfaces
6	39 a 49	Large tree branches move; difficulty in using an umbrella
7	50 a 61	Whole trees move; difficulty walking against the wind
8	62 a 74	Twigs break off trees; movement of people is difficult
9	75 a 88	Damage to trees; unable to walk upwind
10	89 a 102	Trees uprooted; considerable structural damage to buildings
11	103 a 117	Widespread damage to buildings, roofs and trees
12	>118	Devastation to buildings, roofs and trees

Table 4.3. Fast wind speed recognition

Estimated speed	
16 km/h	You can feel the wind in your face
32 km/h	Small tree branches move and snow and dust rise
48 km/h	Large tree branches are moving
64 km/h	Whole trees move

obvious (when we notice it: sweating) or inadvertent (when it happens without us realising it: insensible sweating).

- Sweating: the body sweats to remove excess heat. Body heat is lost by evaporation of moisture from the surface of the skin, so it is important that clothing is not damp with sweat. Wet clothing can result in heat loss through evaporation, conduction, convection and radiation. For this reason it is better to dress in layers, so that we can warm up and disrobe ourselves more easily according to our needs.
- Insensible perspiration: the body also perspires to maintain a humidity level of 70% near the skin; in a cold and dry environment this can lead to significant heat loss.
- Breathing: when breathing, cold, dry air, the air is heated and humidified through moisture that evaporates from the airways, resulting in heat loss through evaporation.

MECHANISMS OF ADAPTATION TO TEMPERATURE CHANGES

- Vasodilatation: dilatation of the blood vessels increases heat loss when the ambient temperature is lower than body temperature. Maximum vasodilatation can increase skin blood flow up to 7,000-8,000 mL/min if the skin is at 41 °C (normally 200-500 mL/min).
- Vasoconstriction: From the point of view of the physiology of cold, the body could be considered as if it were composed of a hot nucleus made up of the internal organs and large vessels, and a cold periphery made up of the skin, the thoracic wall and the extremities. When it is cold, blood vessels become narrowed to reduce heat loss. Maximum vasoconstriction can decrease blood flow to 20-50 mL/min if the skin is at 14 °C.
- Cold induced vasodilatation: when the hand or foot is cooled to 15 °C the maximum vasoconstriction appears and therefore the blood flow to these extremities is reduced to a minimum and they cool down. If they continue to cool to 10 °C, vasoconstriction is interrupted with periods of 5-10 minutes of vasodilatation, which increases blood flow and extends heat to the extremities. Repeated exposure to cold water, for instance about fifteen times, can increase this response and offer a certain degree of acclimatization; the Eskimos have a large vasodilator response (heating of the extremities) with short vasoconstriction intervals (cooling of the extremities).
- Sweating: evaporation of sweat cools the body.
- Shivering: generates heat by increasing the chemical reactions required by muscle activity. Shivering can increase heat production by 500% and raise the core temperature by 0.5 to 4 °C per hour, but this heat is produced in relatively shallow areas and 75% is dissipated into the air. This mechanism is limited to a little more than three hours due to the exhaustion of the muscular glucose consumed when producing the contractions of the shivering muscles, with the consequent appearance of fatigue. For this reason, we administer carbohydrates to the hypothermics swallowed. The shivering threshold is the point to which body temperature must drop before shivering begins; this threshold is 0.5 °C lower in marathon runners and individuals who have been repeatedly exposed to the cold (4 to 7 times for 1 hour between –5 °C and 5 °C in the last two weeks), compared to a control group of untrained and unacclimated individuals.
- Increase and decrease in physical activity: it can increase or decrease body temperature.

Physically fit individuals have a more effective thermoregulatory capacity, as they produce more metabolic heat and greater isolation of the interior of the body through vasoconstriction. Also, a study conducted in Japan in 1992, to find out the optimal preparation for exercise when the ambient temperature was 10 °C, found that the best way to warm up was through moderate intensity and longer duration exercises (30 minutes at 70% of the maximum VO_2 and 30 minutes at 50% of the maximum VO_2), while short duration intense exercise was not very effective.

- Behavioural responses: our brain stimulates us to put on or take off clothes.

Apart from the pathology caused by the cold, it must be taken into account that when the temperature drops below 13 ºC, manual dexterity decreases and it is more difficult to perform activities such as climbing. In addition, shivering further worsens the muscle coordination needed for this type of activity. Prolonged activities in cold climates also have negative psychological effects, such as decreased perception or depression, although the three most important sources of stress are isolation, monotony and lack of interesting entertainment.

5 HYPOTHERMIA

CONCEPT[83]

Accidental hypothermia is defined as the lowering of the body's core temperature to levels where muscle and brain functions do not function correctly, which is a core temperature of less than 35 °C measured at the eardrum with a thermistor thermometer (unreliable in deep hypothermia or if there is snow or earwax in the ear canal) or at the rectum, 15 cm from the anal sphincter (reliable unless in contact with cold stool). If the core temperature is below 24 °C, a transoesophageal thermometer is preferable. The oesophageal or tympanic temperature correlates with the temperature of the pulmonary artery, which is a good reference for the body's central temperature; the rectal temperature is usually 0.4 °C higher, the axillary temperature 0.2 °C lower and the oral temperature 0.4 °C lower. The method of choice is to measure the temperature in the lower third of the oesophagus 24 cm from the larynx.[84]

Temporal artery thermometers are not accurate in cases of hypothermia. Dual-sensor thermometers that combine skin temperature and heat flow have a good correlation with core temperature but have not yet been calibrated in a pre-hospital setting.[85]

EPIDEMIOLOGY[86]

Annual mortality from hypothermia in the U.S. between 1999 and 2002 was of 4 cases per million population. The main risk factors were: age over 65 (almost half), male (2.5:1), cold households, cold clothing, and drug use. The causes of death associated with hypothermia were falls, drowning and cardiovascular disease, although accidental hypothermia is increasingly common in outdoor leisure activities.

In Spain, studies are scarce. In a review of mountain accidents in Aragon over 9 years, it was observed that 1.5% of those involved in an accident had hypothermia as the sole reason for rescue and 2.3% had it associated with other injuries.[87] With regard to hospital emergencies, we only have data from the Puigcerdà Hospital - Cerdanya Hospital Centre with 6 cases per thousand attendances. According to the National Statistics Institute, in the last 9 years 23.7 deaths have been reported annually due to accidental hypothermia, 45% were over 65 years old and the male to female ratio was (3.5:1).

PHYSIOLOGY

Regulation of body temperature

The central body temperature, and that of the brain and organs of the abdominal and thoracic cavities, remains stable between 36.5 °C

Figure 5.1. Arctic touring.

and 37.5 °C thanks to a balance between heat production and loss. Outside these ranges, the thermoregulatory response is activated.

At rest, the body generates 40 to 60 kcal/m^2/h through cell metabolism, viscera (56%) and heart (16%). During physical exercise, it is the muscles and skin that produce 90% of the heat. Heat is lost through the skin and lungs, the processes most frequently involved in accidental hypothermia being convection and conduction through water.

The temperature regulation system is composed of a system of thermoreceptors located in the skin (heat-receptor C amyelinic fibres and cold-receptor A fibres); in the nucleus of the body; in the hypothalamus (preoptic area); and in an integrative hypothalamic centre where adequate thermoregulatory reflex responses are generated.

Thermoreceptors cause the activation of the primary motor centre for shivering, located in the hypothalamus. Through the neurons, signals are sent to the skeletal muscles, which contract rhythmically. Shivering increases the heat output by 2 to 5 times and raises the core temperature by more than 0.5 °C, consuming a significant amount of energy. The threshold for shivering is 1 degree lower than the threshold for vasoconstriction, and is considered a mechanism of last resort for maintaining temperature.

Hypothermia increases adrenal activity (adrenaline and noradrenaline) by stimulating thermogenesis, thyroid activity, releasing T3 and T4 thyroid hormones that increase oxygen consumption, basal metabolism and heat production.

Behavioural thermoregulation is based on the search for appropriate environments, postures and clothing, and the ingestion of water and food.

Pathophysiology of hypothermia

Hypothermia produces functional alterations in the cell membrane, with intracellular fluid leakage, enzymatic dysfunction and electrolyte imbalance (e.g. hyperkalaemia). Oxygen consumption is reduced, due to a decrease in metabolism at low temperatures or by a greater affinity of haemoglobin for oxygen, together with the alteration of oxygen removal from hypothermic tissues.

Hypothermia causes severe platelet dysfunction and inhibition of clotting enzymes, being the main cause of coagulopathy in traumatic shock.

Cell death results from cell membrane damage, protein dysfunction, or intra and extracellular water crystallisation.

Cardiovascular system

Hypothermia decreases the depolarisation of heart pacemaker cells. Atrial and ventricular arrhythmias can be triggered below 32.2 °C due to the sensitivity of the conduction system to cold and the effect on said system of changes in pH, oxygen, electrolytes and nutrients. Below 25-28 °C, asystole and ventricular fibrillation may occur spontaneously.

Average blood pressure and cardiac output decrease. At 25 °C, the cardiac output decreases by 45%.

Nervous system

Hypothermia progressively depresses the central nervous system, with impaired memory and judgment, dysarthria and decreased consciousness. Between 19 °C and 20 °C, the electroencephalogram (EEG) is compatible with brain death.

Respiratory system

Hypothermia causes respiratory depression until ventilation control by the brain stem fails. Ciliary motility is depressed, the amount and viscosity of secretions is increased, non-cardiogenic pulmonary oedema and acute respiratory distress appear. The thorax loses elasticity.

Renal system

Peripheral vasoconstriction is initially translated into a relative central hypervolemia, producing an increase in diuresis, with danger of dehydration. This “cold diuresis” does not efficiently remove nitrogen waste.

Conditions conducing to hypothermia[88]

- **Increased heat loss**
    - Cold temperature: a person buried under an avalanche cools down by 3 °C every hour. Hypothermia is also observed in marathon runners who run at temperatures of 4 to 10 °C, due to the great loss of heat by radiation, convection and evaporation.
    - Altitude: the outside temperature decreases by 0.65 °C per 100 m of altitude (approximately –1 °C per 150 m) or in other words: –6.5 °C per 1,000 m. Therefore, from 3,000 m upwards the temperature is generally below zero.
    - Wind: can multiply the effect of the cold by 10 (see table).
    - Humidity (immersion, rain, sweat) can multiply the effect of cold by 14. Even in the spring and summer months, an unexpected storm without proper clothing can cause hypothermia.
    - Inappropriate equipment.
    - Fatigue.
    - A low percentage of subcutaneous fat. Individuals with high subcutaneous fat values, a percentage of body fat >25% and high muscle mass have limited heat loss.
    - Young people and people over 60 years of age. People over the age of 60 are at increased risk for hypothermia because of their mitigated physiological and behavioural response to cold. Children are also at increased risk due to differences in anthropometric and body composition.
    - Erythroderma: burns, sunburn, psoriasis, ichthyosis, exfoliative dermatitis.
    - Cold drinks.
    - Vasodilatation from drinking alcohol.
    - Open wounds.
- **Decrease in heat production**
    - Energy deficit: hypoglycaemia due to low energy food intake. Hypoglycaemia makes thermogenesis by shivering difficult and increases the risk of hypothermia.
    - Inactivity.
    - Fatigue.
    - Lack of sleep.
    - Endocrinological causes: hypothyroidism, hypopituitarism, adrenal insufficiency, diabetes, hypoglycaemia.
    - Young and old age.
- **Deterioration in thermoregulation**
    - Peripheral cause: neuropathies, trauma, spinal cord injury.
    - Central causes: central nervous system injury, stroke, subarachnoid haemorrhage, hypothalamic dysfunction, Parkinson's, multiple sclerosis, alcohol or drug abuse, drugs.
- **Miscellaneous:** infection, renal failure, lack of knowledge of hypothermia, since neither the victim nor their colleagues detect it or know how to treat it.

Hypothermia and immersion

Hypothermia usually begins to occur when the water temperature is below 25 °C, and cold shock usually occurs when the water temperature is below 20 °C. If the dive lasts longer than 30-60 minutes, the risk of death from hypothermia is high.

Table 5.1. Approximate survival time in cold water

Water temperature	Estimated time of survival
0 °C	10 min
5 °C	30 min
10 °C	1.5 h
15 °C	6 h

Figure 5.2. Ice climbing.

CLINICAL PRESENTATION

When the body begins to cool down, heat production (shivering) increases and loss of heat (vasoconstriction) decreases. At around 33 °C, the production of heat gives way and subsequently the mechanisms that prevent heat loss fail, leading to self-sustaining hypothermia at around 30 °C.

Some patients are cold but not hypothermic. Shivering is a mechanism to prevent hypothermia, some patients may have uncontrollable shivering at >35 °C. Clinically, if a patient who is shivering is able to take care of themself and retains abilities properly, said patient is probably not hypothermic. However, if they have a disability and are unable to take care of themselves, they may be hypothermic. If in doubt, assume it is hypothermia.[85]

In its acute form (avalanche, cold water immersion) there are no intravascular changes (hypoglycaemia) that exist in the subacute

Table 5.2. Clinical manifestations of hypothermia[89]

Stage	Central temperature	Signs and symptoms
Light hypothermia – Stress due to cold	36-37 °C	Normal, you can start shivering.
	35-36 °C	Feeling cold, cold skin; if it is hot, it is not hypothermia. More intense shivering, but it can still be stopped voluntarily. Negative attitude and loss of interest. Loss of motor coordination due to restricted peripheral blood flow: complex tasks cannot be performed with the hands (skiing or climbing), but walking and talking is still possible.
Hypothermia grade I	32-35 °C	A violent shivering that cannot be stopped voluntarily. Awareness, although there may be speech disorders, confusion and lethargy. Worse muscle coordination: not possible to do up a zipper. Slow movements. You stumble: if you can't take 30 steps in a straight line, you may have hypothermia. Irrational behaviour: the hypothermic person takes off their clothes despite the cold.
Hypothermia grade II	30-32 °C	Shivering stops despite the cold. Disorders of consciousness: apathy, confusion, delirium. Irrational and incoherent behaviour, but one can maintain the position and a certain appearance of coherence. Bluish skin. Very poor muscle coordination: you cannot walk, you stay in the foetal position to keep warm. The radial pulse is not felt due to vascular collapse, but the carotid artery is still felt.
	28-30 °C	Muscle stiffness (DOMS) due to the accumulation of lactic acid produced by the reduction of peripheral blood flow. Semi-consciousness, stupor. At 32 °C the body tries to hibernate, reduces peripheral blood flow and decreases heart and breathing rate. Possible ventricular fibrillation (severe arrhythmia). Pupil dilatation. At 30 °C the hypothermic person appears dead but may be alive: if they are in the foetal position and when the arm is separated it returns to the foetal position, the person is alive.
Hypothermia grade III	26-28 °C	Unconsciousness. Erratic breathing and heart rate, carotid pulse may not be palpable. Non-reactive pupils.
	24-28 °C	Pulmonary oedema, cardiorespiratory failure, ventricular fibrillation, death. When the core temperature is between 28-32 °C, the mortality rate is 21%.

Table 5.2. (Cont.) Clinical manifestations of hypothermia[89]

Stage	Central temperature	Signs and symptoms
Hypothermia grade IV	13.7?-24 °C	Apparent death, no vital signs are observed but the chest is compressible and the abdominal muscles depressible. At 17 °C the EEG is flat.
Hypothermia grade V	Below 13.7 °C or perhaps 9 °C?	Death. No vital signs are seen, the chest is not compressible, and the abdominal muscles are not depressible. The lowest core temperature at which survival in accidental hypothermia has been recorded is 13.7 °C in adults and 15 °C in children. The lowest core temperature at which survival in therapeutic hypothermia has been recorded is 9 °C.

form (warm water immersion, fatigue). The subchronic form due to prolonged exposure to a cold, not very intense environment is accompanied by serious complications such as rhabdomyolysis, metabolic acidosis, renal failure and hypovolaemia and has a high mortality rate (elderly person immobilised by fracture in a cold room).

COMPLEMENTARY EXPLORATIONS

In moderate or severe hypothermia, complementary tests are useful to identify possible complications such as lactic acidosis, rhabdomyolysis or bleeding diathesis.

Blood values

Determination of blood glucose, serum electrolytes including potassium and calcium, urea and creatinine, blood count, serum lactate, fibrinogen, creatine phosphokinase, and arterial blood gases without temperature correction may be helpful.

Due to volume depletion as a result of cold diuresis, haematocrit increases by 2% for every 1 °C drop in temperature. Leukocytes are normal or low even in the presence of sepsis due to bone marrow depression and liver, splenic and splanchnic sequestration. For the same reason, bleeding from secondary thrombocytopenia may occur.

Acute hypothermia may occur with hyperglycaemia, while subacute or chronic hypoglycaemia may occur. Hyperglycaemia that persists during rewarming suggests pancreatitis or diabetic ketoacidosis. Insulin is ineffective below 30 °C.

Hypothermia can mask ECG changes commonly associated with hyperkalaemia. A potassium concentration of 8 mmol/L or greater is associated with a very low risk of recovery. Chronic hypothermia can lead to hypokalaemia.

Rewarming can be accompanied by rapid and unpredictable changes in electrolyte concentrations, so in moderate and severe hypothermia they should be re-evaluated frequently (about every 4 hours).

A clinically evident coagulopathy may not be reflected by apparently normal laboratory values, as coagulation tests are always performed at 37 °C in the laboratory and will be reported as “normal” even though there may be obvious “in vivo” coagulopathy. Treatment involves rewarming, as simple administration of clotting factors may not be effective.

The evaluation of oxygenation is also complicated by the fact that arterial blood gas analysers operate at 37 °C. Arterial blood gas concentrations may show higher concentrations of oxygen and carbon dioxide and a lower pH than the patient’s actual values.

Electrocardiogram

Regardless arrhythmogenic complications, hypothermia causes ECG changes due to delayed conduction of the impulse through the potassium channels, extending all ECG intervals.

Below 32.2 °C the characteristic J wave or Osborn wave appears (only if the ST segment is not altered) representing the distortion of the early phase of membrane repolarisation and is more noticeable in shunts II and V6. The height of the Osborn wave is approximately proportional to the degree of hypothermia. Shivering can cause rhythmic irregularities in the ECG and occasionally the QRS complex. The software available for ECG interpretation does not recognise Osborn waves, and confuses them with ischemic changes (Fig. 5.3).

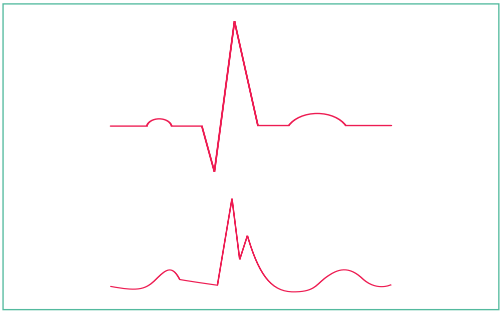


Figure 5.3. Normal ECG and Osborn J wave.

Radiology

A thoracic x-ray is indicated in patients with hypoxia. Aspiration pneumonia and pulmonary oedema are common findings.

CLASSIFICATION

Table 5.3. Classification of hypothermia on the Swiss scale

Hypothermia grade I	35-32 °C	conscious, trembling
Hypothermia grade II	32-28 °C	low level of consciousness, no tremor
Hypothermia grade III	28-24 °C	unaware
Hypothermia grade IV	24-15 °C	apparent death
Hypothermia grade V	<15 to 9 °C?	death by irreversible hypothermia

Mortality in grade I and II hypothermia is usually less than 5%, although a multicentre study finds a 21% mortality in grade II hypothermia; from grade III on, it is greater than 50%. A case of recovery without consequences has been reported in a woman who had spent 40 minutes immersed in cold water and had a core temperature of 13.7 °C.

PREVENTION

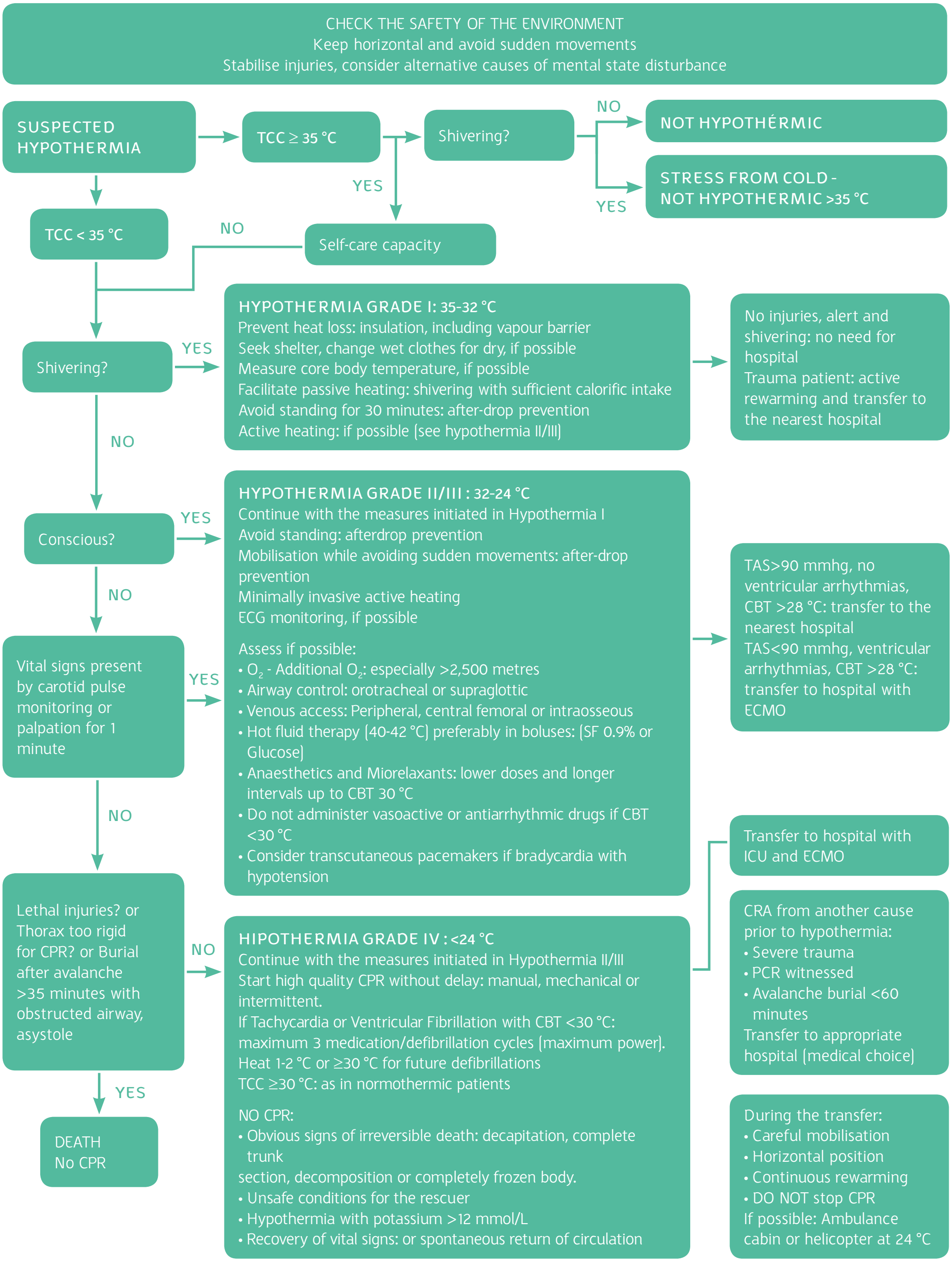
Physical fitness, by itself, does not improve the thermoregulatory response to cold. But it allows you to exercise for longer and helps to maintain the core temperature **(C)**.

Energy consumption is 10-40% higher in cold weather. Intake of carbohydrates in the form of sweetened hot drinks reduces the risk of hypothermia **(C)**.

Clothing protects against cold injury by reducing heat loss by air trapped within the clothing and between the different layers **(C)**. Clothing should consist of several layers that eliminate sweat and protect against wind and rain.

- The inner layer should remove sweat and moisture to the outside, keep the skin dry and retain heat. For example, fibre t-shirt (polypropylene, thermostat, Coolmax, etc.).
- The outer layer should insulate from wind, snow and rain, but it should also allow the elimination of sweat (Gore-Tex, sympatex and similar fibres).
  - **Waterproofing** is measured in millimetres of water and usually ranges from 2,000 to 20,000 millimetres; other units such as bar (equivalent to 10,000 millimetres) or PSI (pounds per square inch, equivalent to 700 millimetres) are used; the higher the value, the more waterproof the fabric. A fabric rated at 25 PSI or 10,000 mm is waterproof enough for many mountain activities. For a technical garment a rating of 40 PSI or 20,000 mm is preferable.
  - **Breathability** is measured in RET (resistance to perspiration); the lower the resistance, the more breathable the fabric. A mountaineering garment should have a minimum RET of 60. It is also possible to measure the grams of perspiration that can pass through the m^2 of fabric every 24 hours. In this case, the more grams that pass through, the better. A garment for mountaineering should pass 20,000 $g/m^2/24$ hours.

Flow chart 5.1. Prehospital management of accidental hypothermia[85, 92]. Adapted by Avellanas, M.; Ayala, M.; Soteras and Subirats, E. (2018).



CHECK THE SAFETY OF THE ENVIRONMENT
Keep horizontal and avoid sudden movements
Stabilise injuries, consider alternative causes of mental state disturbance

SUSPECTED HYPOTHERMIA

TCC ≥ 35 °C

Shivering?

NOT HYPOTHÉRMIC

STRESS FROM COLD -
NOT HYPOTHERMIC >35 °C

TCC < 35 °C

Self-care capacity

Shivering?

HYPOTHERMIA GRADE I: 35-32 °C
Prevent heat loss: insulation, including vapour barrier
Seek shelter, change wet clothes for dry, if possible
Measure core body temperature, if possible
Facilitate passive heating: shivering with sufficient calorific intake
Avoid standing for 30 minutes: after-drop prevention
Active heating: if possible (see hypothermia II/III)

No injuries, alert and shivering: no need for hospital
Trauma patient: active rewarming and transfer to the nearest hospital

Conscious?

HYPOTHERMIA GRADE II/III : 32-24 °C
Continue with the measures initiated in Hypothermia I
Avoid standing: afterdrop prevention
Mobilisation while avoiding sudden movements: after-drop prevention
Minimally invasive active heating
ECG monitoring, if possible

Assess if possible:
- O_2 - Additional O_2: especially >2,500 metres
- Airway control: orotracheal or supraglottic
- Venous access: Peripheral, central femoral or intraosseous
- Hot fluid therapy (40-42 °C) preferably in boluses: (SF 0.9% or Glucose)
- Anaesthetics and Miorelaxants: lower doses and longer intervals up to CBT 30 °C
- Do not administer vasoactive or antiarrhythmic drugs if CBT <30 °C
- Consider transcutaneous pacemakers if bradycardia with hypotension

TAS>90 mmhg, no ventricular arrhythmias, CBT >28 °C: transfer to the nearest hospital
TAS<90 mmhg, ventricular arrhythmias, CBT >28 °C: transfer to hospital with ECMO

Vital signs present by carotid pulse monitoring or palpation for 1 minute

Lethal injuries? or Thorax too rigid for CPR? or Burial after avalanche >35 minutes with obstructed airway, asystole

DEATH
No CPR

HIPOTHERMIA GRADE IV : <24 °C
Continue with the measures initiated in Hypothermia II/III
Start high quality CPR without delay: manual, mechanical or intermittent.
If Tachycardia or Ventricular Fibrillation with CBT <30 °C: maximum 3 medication/defibrillation cycles (maximum power).
Heat 1-2 °C or ≥30 °C for future defibrillations
TCC ≥30 °C: as in normothermic patients

NO CPR:
- Obvious signs of irreversible death: decapitation, complete trunk

section, decomposition or completely frozen body.
- Unsafe conditions for the rescuer
- Hypothermia with potassium >12 mmol/L
- Recovery of vital signs: or spontaneous return of circulation

Transfer to hospital with ICU and ECMO

CRA from another cause prior to hypothermia:
- Severe trauma
- PCR witnessed
- Avalanche burial <60 minutes

Transfer to appropriate hospital (medical choice)

During the transfer:
- Careful mobilisation
- Horizontal position
- Continuous rewarming
- DO NOT stop CPR

If possible: Ambulance cabin or helicopter at 24 °C

(CRA: Cardiorespiratory arrest; CPR: cardiopulmonary resuscitation; SBP: Systolic blood pressure. CBT: Core body temperature; ECMO: Extracorporeal membrane oxygenation; ICU: Intensive care unit; ECMO: Extracorporeal membrane oxygenation)

  - Another value measures the amount of air passing through the fabric with a simulated wind speed of 50 km/h. It is **CFM** (cubic feet per minute) and it should be 0.
  - Many fabrics have long-lasting water resistance **(DRW)** treatments, whose effectiveness is measured by spray-testing. A fabric with an 80/20 spray-test means that after 20 washes it retains its water-repellent properties intact on 80% of its surface and is already considered good. Only a few treatments can achieve 80/100 results.
- The intermediate layers should retain the heat generated by the body and allow for the removal of moisture (e.g. fleece or garments with artificial fibres or duvets).
  - The standard unit of insulation for garments is the Clo; a Clo is the insulation necessary for a seated adult to maintain comfort in a room with a temperature of 21 °C, a relative humidity of 50% or less and in which the air moves at 6 m/min. At −20 °C you would need 12 Clo sleeping bags, 3 Clo clothes for soft activity and 1 Clo for intense activity.
  - Recently, thermal resistance (Rct) has been used as a measure of insulation. For temperatures below −5 °C, garments must have a thermal resistance of at least 0.310 m^2 K/W (K: Kelvin degrees, W: watts). If the temperature is +10 °C, the Rct must be higher than 0.17. The labels mark the protection from 1 to 3 (Rct between 0.18 and 0.25).
  - The fleece lining is manufactured in 3 weights (100, 200 and 300), each thicker and more insulating than the previous one. The most versatile is the 200.
  - Down garments are filled with a proportion of down and feather. The minimum acceptable for a technical garment is 80% down (80/20). Optimum mixtures have a 95% (95/5) mix. A more reliable indicator of its insulation capacity is the ‘fill power’ in cubic inches (cu in), which for mountaineering should have a capacity of 600-900 cu ins.
  - Some athletes prefer not to wear natural feathers at the poles, as moisture causes the down to get wet, clump and freeze. Primaloft does not have the thermal capacity of natural down, but neither does it have these drawbacks.
- Do not forget to wear several pairs of gloves. The same philosophy can be applied to gloves as to layered clothing. Natural fibres absorb moisture, which is why synthetic fibre gloves are preferred, as classic silk gloves absorb sweat and this can freeze inside the glove.
- Remember that wool is a good insulator and retains its properties even when wet, while cotton loses its properties when wet.
- It is advisable to take off clothes before doing intense exercise to avoid getting wet with sweat, as it moistens the clothes, reducing their insulating capacity and increasing the heat loss when they evaporate. When resting, put on dry clothes and warm yourself, without waiting for cold weather, as it would take more heat to warm your body again.
- It is advisable to wear a light-coloured hat that protects against both the sun and the cold, as 20-30% of heat loss is through the head.
- Wearing a hat and a windbreaker jacket and trousers during exercise in cold weather can reduce the risk of hypothermia.[90]

Although the temperature decreases with altitude, it is frequent that in anticyclonic winter weather there is a thermal inversion and temperatures are more pleasant half way up a mountain than at the bottom of the valley, which should be taken into account if you plan to camp or bivouac.

If submerging in cold water, do so slowly and progressively, keeping your head out of the water, trying to minimise your exposure to the cold water and keeping your breathing under control. In the event of a fall into cold water, you have 1 minute to get your breathing under control by avoiding panic, 10 minutes to try to get out of the water and 1 hour before you lose consciousness due to hypothermia. Excessive movement in the water increases heat loss, so it is preferable to be still. In the case of a fall into an icy lake due to broken ice, place the body horizontally, place your arms on top of the ice and try to swim and crawl out of the hole until the ice is thick enough to support the weight of your body when standing up; if it is possible, carry a knife; it makes it easier to progress through the ice.

TREATMENT[84-86, 91]

Initial treatment

If the victim is not in cardio-respiratory arrest, initial attention is directed to life support and avoiding further heat loss. To do this wet clothes are removed, the victim is covered, insulated from the ground and protected from the wind, and then the rewarming process is initiated according to the degree of hypothermia. Sudden movements should be avoided when undressing and exploring the patient as they may precipitate cardiac arrhythmias.

A general examination is then performed to look for local injuries due to cold, or signs of trauma.

Temperature measurement

The core temperature acts as a guide in treatment of accidental hypothermia. The axillary, rectal, oral or temporal artery thermometer measurements are inaccurate, the oesophageal **(C)** or bladder temperature correlates better with that of the pulmonary artery considered the gold standard, but measurement is not feasible outside hospital and is uncomfortable for a conscious patient. Outside hospital, therefore, epitympanic measurement is used, using an electronic probe (thermistor) isolating the auditory canal, as it is simple, fast, comfortable and precise, although it is limited in patients with deep hypothermia and in patients buried by avalanche with snow-filled ear canals[85] **(C)**. The Swiss scale for measuring the degree of hypothermia without the need for a thermometer can be useful in the field.

Airway, ventilation and circulation

The initial evaluation of hypothermia includes airway, ventilation and circulation control.

In the out-of-hospital setting, the objective is to isolate the airway and oxygenate without delaying the transfer. Endotracheal intubation is performed in patients with loss of protective airway reflexes to prevent bronchoaspiration. With adequate pre-oxygenation, death associated with such a manoeuvre is rare. The use of muscle relaxants below 30 °C is controversial because of their ineffectiveness and unpredictable elimination.

If possible, humidified warm oxygen is used. The response time of digital pulse oximeters is slowed, but if they are placed on the auricle or forehead, the measurement is less influenced by body temperature.

Cardiovascular assessment is difficult because the pulse is slow and irregular. The pulse in the carotid artery should be felt or the ECG should be observed for 1 min, looking for signs of life before concluding cardiac arrest and starting CPR manoeuvres.

If ventricular fibrillation below 30 °C is diagnosed, defibrillation may be attempted, but adrenaline and amiodarone should not be given, as they will be ineffective. Once this temperature is reached, intervals between doses should be doubled or the doses themselves halved due to slowed metabolism. A transcutaneous pacemaker may be effective for bradyarrhythmia, but not an endocavitary pacemaker.

Moderate or severe hypothermia produces hypotension by depletion of intravascular volume. Replenishment is carried out with heated fluids, preferably crystalloids, avoiding lactated Ringer's solution since a hypothermic liver will not metabolise it. Central perfusion is not recommended because of the risk of inducing arrhythmias, except via the femoral artery.

In refractory hypotension with normovolaemia, vasoactive drugs may be given in case they are effective. Volume overload that would impair myocardial contractility should be avoided.

In the out-of-hospital setting, "the art of the possible" is practised; canalisation of peripheral pathways should not delay the transfer, but cardiac monitoring should be attempted to detect any possible ventricular fibrillation.

Cardiac arrest: decision to resuscitate

You must be cautious before diagnosing the death of a hypothermic person. At 18 °C the brain can withstand circulatory arrest for 10 times longer than at 37 °C. Pupillary dilation, absence of corneal reflex or lividity are not considered signs of death. The lowest core recorded temperatures at which accidental hypothermia was survived are 13.7 °C in adults and 15 °C in children. In therapeutic hypothermia it is 9 °C.

Resuscitation should not be initiated if there are lethal lesions or if the chest is not compressible. If resuscitation cannot be provided without interruption during the transfer, it may be postponed for a maximum of 10 minutes, or it may be performed intermittently until it can be performed continuously.

In case of intermittent resuscitation, it is performed in the following manner:

- If the core temperature is below 28 °C or unknown, 5 minutes of cardiopulmonary resuscitation (CPR) and 5 minutes without CPR are alternated.
- If the core temperature is below 20 °C, 5 minutes of cardiopulmonary resuscitation (CPR) alternate with 10 minutes without CPR.

Serum K^+ is determined in the hospital; when it is greater than 8 mmol/L in cases of hypothermia and hypoxia by burial in avalanche, or 12 mmol/L in cases of hypoxic-free hypothermia, stop the resuscitation manoeuvres. Otherwise, they are continued until the death is proven after rewarming.[2]

Table 5.4. Criteria to decide the reversibility of hypothermia in situ.

	Hypothermia IV	Hypothermia V
Clinical findings	No vital signs Compressible thorax Depressible abdomen	No vital signs Non-compressible thorax Non-depressible abdomen
ECG	Ventricular fibrillation / Asystole	Asystole
Core temperature	>15 °C	<15 °C
Potassium	<8 mmol/L	>8 mmol/L

Rewarming

Rewarming improves survival; the controversy lies in the method of rewarming, which will depend on the characteristics of the patient, the degree of hypothermia and the experience of the health centre. Response to minimally invasive rewarming techniques is unpredictable, and it is not clear if a combination of rewarming methods will have an additive effect.

There are three methods of rewarming: passive, active external and active internal. They are based on preventing heat loss and gradually warming the victim up while they are being transferred to hospital **(B)**.

The specific heat of a substance is the amount of heat required to raise its temperature by 1 °C; the human body requires 0.83 kcal/kg/°C and water, 1 kcal/kg/°C. For example, 498 Kcal are required to raise the temperature of a 75 kg victim from 27 °C to 35 °C.

Passive external rewarming

Is based on minimising the heat losses produced by the body itself. It is the method of choice in mild hypothermia and an additional method in moderate and severe hypothermia.

Hibler method

Hibler's method is the out-of-hospital method of choice and most effective for preventing heat loss, increasing skin temperature, reducing metabolic rate, and improving patient comfort. It consists of a combination of a vapour-tight layer and an additional layer of dry insulation:[93] the victim is protected from wind and cold; a few pieces of cloth are folded (e.g. a linen towel) and moistened with hot water (tea or coffee from the thermos flask can be used) and then the hot, damp cloths are placed on the patient's chest and abdomen, preferably on the neck, armpits and groin. The damp cloth is not placed directly on the skin, but on the underwear to avoid burns.

The torso —not the extremities— is then wrapped in an insulation blanket with the silver side towards the body, reflecting 80% of the radiant heat from the body. Finally a second blanket is wrapped around them.

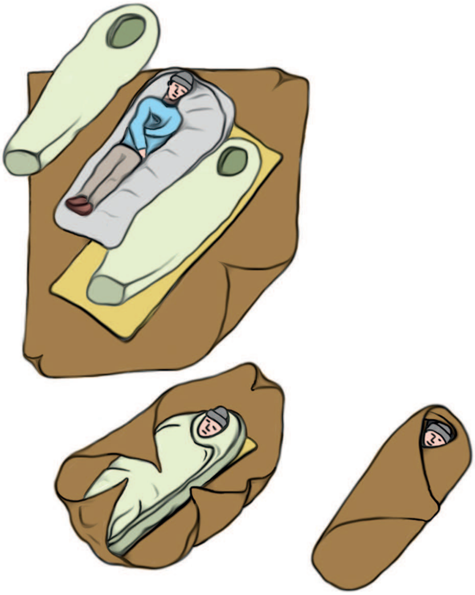


Figure 5.5. Hibler method.

The trunk is heated before the extremities to avoid relapse of central body temperature as well as hypotension and acidosis due to vasodilatation, so the extremities are initially exposed[94] **(C)**.

Mexican burrito method

An alternative is to wrap the victim in dry layers, placing the most insulating ones close to the ground and the ones with the highest thermal capacity in contact with the victim. If possible this is combined with active external reheating methods (heat packs, etc.). Plastic bubble wrap can be useful as an insulator.[95]

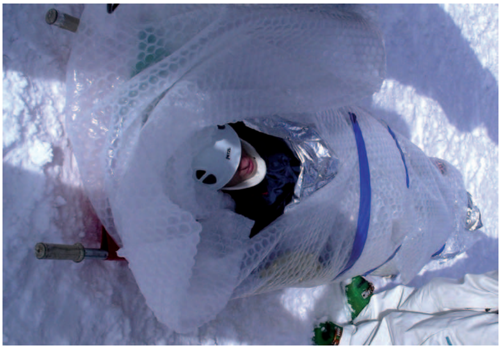


Figure 5.5. Mexican burrito.

These methods are slow and require the person with hypothermia to have a certain capacity to produce heat (thermogenesis), so they are not very useful when shivering has stopped (core temperature below 32 °C). The rewarming rate is of the order of 0.5 to 2 °C/hour; if it is lower, or if arrhythmias and haemodynamic instability occur, active rewarming will be initiated.

Active external rewarming

Is indicated in moderate to severe hypothermia (<32 °C) and mild hypothermia that does not respond to passive external warming. It consists of applying heat from the outside so that the person with the hypothermia warms up from the outside inwards.

Radiant heat sources commonly used are:

- Body-to-body rewarming, similar in effectiveness to passive rewarming in a shivering patient and slightly more effective in a non-shivering patient **(B)**.
- Applying hot air by means of a heater such as a HeatPac® **(C)**.

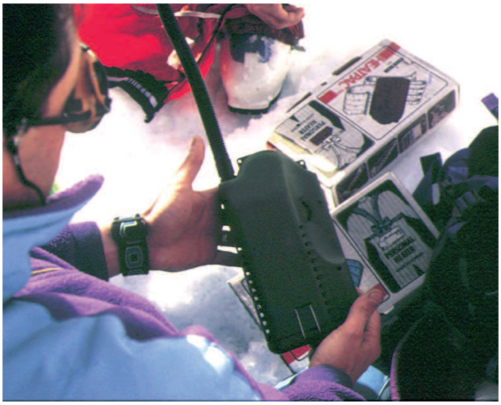


Figure 5.6. Heat pack.

- Placing hot water bottles at 55 °C, or heat-producing bags on the trunk, neck, armpits, sides of the chest and groin, and insulating to prevent heat loss. Do not place the heat sources directly on the skin to avoid damaging it; they must be wrapped in some cloth **(B)**.
- Actively warming blankets (UniqueResc+ Geratherm® Rescue System).

- Hot air systems that prevent heat loss by convection such as BairHugger®.
- A hot spot can be created by covering the patient with an insulating aluminised blanket, as if they were inside a tent, and placing a heat source inside it (candle, stove, etc.).

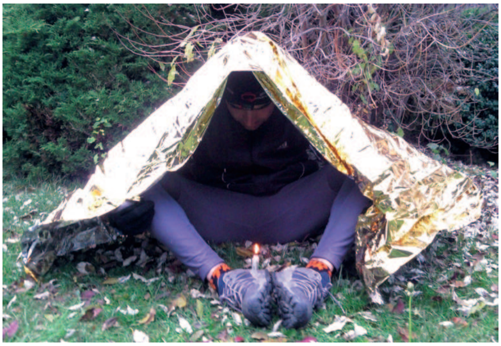


Figure 5.7. Hot spot.

The effectiveness of full-body or limb hot water baths and low-frequency microwaves and ultrasound is controversial. The approximate warm-up rate is 2 °C/hour. Peripheral vasoconstriction of the hypothermic person increases susceptibility to burns and therefore the skin must be monitored.

Active internal rewarming

Is used in severe or moderate hypothermia that does not respond to external warming. It consists of applying heat to the inside of the hypothermic person in order to heat them up from the inside out.

Minimally invasive techniques

Perfusion of hot crystalloid sera (40 °C - 42 °C). The heat transfer of 1 litre of physiological saline solution is 1 kcal/kg/°C. If one litre of serum at 42 °C is perfused into a 75 kg hypothermic patient with a temperature of 27 °C, 1 kg x (42-27 °C) = 15 kcals are transferred, and the temperature rise is 15 kcal/ 0.83/75 = 0.24 °C. Although the temperature rise is small, a 1-2 °C increase can be life-saving.[41] Warming can be greater if the infusion is done quickly and with a very short (<25 cm) serum set. It may be sufficient to prevent the hypothermia worsening, but not to heat an established hypothermia **(B)**.

Hot air inhalation. The rate of re-warming is 0.5 °C/h. Moistened oxygen, even without being heated, prevents heat loss by evaporation. Humidifiers can heat the air to 41 °C, increasing its efficiency. In an out-of-hospital setting there are portable systems such as Res-q-air® and Little Dragon®, which are rarely used due to their scarce distribution or lack of evidence, respectively. The air heating function of the BiPAP devices available in many emergency departments can be used to heat the inhaled air by simply neutralising the other functions on the device. (Grade C recommendation)

Intravascular heating systems like the Thermogard System® are in developmental stage. They are heated from a central catheter and appear to be as effective (3 °C/h) and a less invasive alternative to extracorporeal re-warming.

Invasive techniques

Cavity washing: stomach, bladder and colon lavage with hot serum are ineffective due to the limited surface area of the mucous membranes for heat exchange.

Pleural cavity lavage: is performed on the right hemithorax to avoid cardiac irritability. A thoracic drainage tube is used to perfuse 200-300 mL of physiological saline solution at 42 °C followed by subsequent drainage. This is used when other techniques have failed or the chest tube is already in place for another reason.

Mediastinal irrigation: the heart is bathed in physiological saline solution at 40 °C; it has recently been used effectively in conjunction with cardiac massage and cardiopulmonary by-pass. Use only when the victim is in cardiac arrest and the medical centre has sufficient resources and experience.

Peritoneal lavage: 10-20 mL/kg of saline or dialysis solution are infused at 42 °C, left for 20 minutes and then removed. With two inflow paths, a flow rate of 6 L/h is obtained. This technique also eliminates any existing toxic substances due to renal failure and associated rhabdomyolysis.

Extracorporeal methods

Continuous veno-venous hemofiltration (CV-VHF): the blood from the femoral vein is pumped with a flow rate of 150-400 mL/h, heated by a machine and then reinfused into another vein. The rate of rewarming is 2 to 3 °C/hour.

Haemodialysis provides a similar rate of rewarming and is useful in the context of kidney insufficiency, electrolyte disturbances, volume overload and dialyzable toxins. The advantage lies in the wide availability and quick implementation of the treatment. If hypothermia has been present for more than 3 hours, extracorporeal circulation does not seem to be better than haemodialysis as a method for rewarming.[97-102]

Continuous arteriovenous rewarming is a system that requires no pump or heparin. The technique is similar to continuous arteriovenous hemofiltration. Through a femoral catheter and thanks to the patient's blood pressure, the blood is pumped into a fluid heater. A systolic pressure greater than 60 mmHg is required. The rate of rewarming is 3 to 4 °C/hour.

Cardiopulmonary bypass: can reheat up to a rate of 8 °C /hour. The survival of 32 cases with a severe hypothermia in cardiac arrest was 50%. It is considered the "gold standard" of warm-up in hypothermia with cardiorespiratory arrest. The disadvantages lie in limited availability, delayed treatment and the need for anticoagulation.

Extracorporeal oxygenation membrane (ECMO)

Extracorporeal membrane oxygenation (ECMO) is an extracorporeal system that provides the heart and lungs with oxygen when they are so damaged that they do not function. It is used both in complications (e.g. pulmonary reperfusion oedema) and in prolonged weaning after cardio-pulmonary bypass, improving survival. This technique offers greater survival rates and is preferable to cardiopulmonary bypass **(B)**.

Decrease in core body temperature (after drop) and collapses due to rewarming.

Relapse of core body temperature (after drop) may occur even if the exposure to cold

Table 5.5. Rewarming methods

External methods	Internal methods
Spontaneous gradual reheating → 1.2 °C/h	Ventilation with hot air (45 °C): with mask → 0.7 °C/h with tracheal tube → 1.2 °C/h (*The Res-Q-Air appliance is often used. In our environment we use the heating option offered by the BiPAP appliance)
Hot blankets à 0.9 °C/h Heat producing bags → 1.4 °C/h	Peritoneal lavage, after thoracoabdominal radiological examination (45 °C to 4 L/h) → 3 °C/h
Inmersión en agua a 42 °C → 10,1 °C/h	Extracorporeal circulation → 8 - 10 °C/h
	Gastric lavage with 200-300 mL of physiological saline solution at 45 °C, left for 15 minutes in the stomach and then aspirated to avoid hydroelectrolyte imbalances due to its absorption.→ 2.8 °C/h
	Hot serum perfusions (can be heated for 2 minutes in the microwave if the bottle is made of plastic) at 43 °C → 0.3 °C/h. at 65 °C → 2.9 °C/h
	Pleural lavage at 500 mL/min → 6.1 °C/h at 2 L/min → 19.7 °C/h
	Haemodialysis (200-500 mL/min) → 2-3 °C/h

ceases. Although this decrease has been estimated at 2 °C, it may be important in critical patients near the ventricular fibrillation threshold. Currently, with active reheating and temperature monitoring, no cases have been reported.

Overheating collapse is the drastic drop in blood pressure due to hypovolaemia or arrhythmias, triggered by manoeuvres such as moving the victim abruptly. This may be a cardiogenic shock due to decreased cardiac output caused by changes in the intracellular Ca^{++} exchange.

Other therapeutic measures

- Hot sugary drinks, if possible given every 15 minutes to an affected person that is able to swallow. Sugar is more important than the hot drink, as shivering is a mechanism for producing heat and muscles need glucose as fuel for shivering. This behaviour is beneficial when the evacuation is delayed **(C)**.
- Do not give alcohol as, being vasodilator, it increases peripheral heat loss.
- Do not give tobacco as, being vasoconstrictive, it increases the risk of frostbite.
- Treat concomitant injuries. If immobilisation is required, do so carefully so as not to cause additional injury to frozen tissues **(C)**.
- Move very gently, if possible in a horizontal position and without manipulating the limbs; do not perform sudden manipulations to avoid precipitating the relapse of the core temperature. For the same reason, when removing clothing it should be done with great care; it may be best to cut it off to remove it without moving the victim too much **(B)**.

Treatment of hypothermia, depending on the severity

Hypothermia grade I (The victim is conscious and trembling)

- Initiate external heating
- Accident victims who have a vigorous shivering will rarely need to be taken to the hospital.
- Transfer to the hospital if the outcome is not good following the general recommendations.

Hypothermia grade II (The victim doesn't shiver. There is a risk of lethal arrhythmias)

- Place horizontally to minimise relapse of core body temperature and overheating collapse **(B)**.
- Initiate external heating **(B)**.
- Transfer to a hospital with an intensive care unit (ICU).
- If a delay in evacuation is foreseen, assess the placement of a venous line (difficult because of vasoconstriction) and perfusion of 250-500 mL of warm 5% physiological saline solution.

Hypothermia grade III (The victim has a significant decrease in consciousness but has vital signs. The risk of lethal arrhythmias is very high)

- Place in a horizontal position to avoid a relapse of core body temperature and overheating collapse.
- Initiate external rewarming.
- If there are protective reflexes of the airway: assess the placement of a venous line (difficult because of vasoconstriction) and perfusion of 250-500 mL of warm 5% physiological saline. The start of the intravenous therapy should not delay the transfer of the patient to the hospital.
- If there are no protective reflexes of the airway: orotracheal intubation with adequate pre-oxygenation.
- Transfer to a hospital with an extracorporeal circulation unit or extracorporeal oxygenation membrane, as this is the treatment of choice in these cases.
- In mountain hospitals, peritoneal lavage and intravenous infusions can be performed at a prudent pace with hot sera (45 °C), respiratory ventilation with humidified air with hot sera at 42 °C, and even haemodialysis with hot liquids, but these measures only serve to limit the aggravation while the victim is

transferred to a hospital with extracorporeal circulation. In urgent situations, fluids that do not contain glucose or blood can be heated in a microwave oven.

Hypothermia grade IV (The victim has no vital signs, apparent death)

- If there is no carotid pulse after feeling for 60 seconds, start CPR. Remember that the radial pulse is absent below 33 °C and pupillary dilation has no prognostic value in hypothermic arrest victims. Breathing is done via mouth-mask in order to breathe warm air.
- When CPR cannot be performed continuously, it may be delayed for 10 minutes or may be performed intermittently. In patients with core temperature <28 °C or unknown, 5 minutes of CPR with 5 minutes without compression may be alternated. In patients with core temperature <20 °C, 5 minutes of CPR may alternate with 10 minutes without compressions.[103]
- Chest compressions are not indicated when:
    - The victim has been immersed in cold water for more than an hour.
    - The core temperature is below 10 °C.
    - A lethal lesion (e.g. decapitation) is observed.
    - The person is frozen (e.g. ice in the airways).
    - The chest wall is so rigid that compressions are not possible.
    - Rescuers are exhausted or in danger.
    - A health centre is available within three hours.
- Assess the placement of a venous line (difficult because of vasoconstriction) and a hot perfusion of 250-500 mL of 5% saline solution. Most hypothermic people are dehydrated and may require fluid perfusion. Perfusion in 250 cm^3 bolus is preferable to continuous perfusion. Perfuse the bolus needed to maintain blood volume. Ringer's serum is not recommended because of the inability of the hypothermic liver to metabolise lactate. The sera should be heated to 38-45 °C.
- Recommendations for drug administration: Because of the slowing of metabolism in the hypothermic patient, drugs given at normal doses can be toxic when the patient returns to normal temperature. Therefore, start by giving the minimum dose and doubling the time between doses.
- Orotracheal intubation. Intubation may be risky in the hypothermic patient as it could lead to ventricular fibrillation (severe arrhythmia); consequently, it can only be performed by highly trained personnel and if the airway is actually compromised. When performed in this way, no increased incidence of ventricular fibrillation has been observed. Assess intubation through a Fastrach type laryngeal mask because it is easy and quick.
- Pulse oximetry may not be reliable due to vasoconstriction; the use of topical methylsalicylate as a vasodilator should be considered. During reheating it is advisable to administer oxygen, because oxygen consumption increases three times for every 1 °C increase in temperature. If oxygen is administered, try to do so with hot air (42-46 °C) and humidified if possible.
- Temperature measurement:
    - If the temperature is above 32 °C and CPR is effective, transfer to hospital.
    - If the temperature is between 32-15 °C, perform an electrocardiogram, if possible.
    - If ventricular fibrillation or asystole is observed without asphyxiation, remember that although defibrillation is ineffective below 28 °C, a 360-J shock test may be performed; if it is not effective, it is repeated when the victim has reached 30 °C. Arrhythmias can occur below 30 °C; the maximum susceptibility is around 22 °C. Lidocaine is ineffective in hypothermia-induced arrhythmias. When the patient is above 28 °C or if the patient›s temperature is unknown, they should be treated as if their temperature were normal. There is one case of successful defibrillation at 20.4 °C.[104]
    - If asystole with asphyxia (e.g. snow-filled mouth from an avalanche) is observed upon arrival at the hospital, perform a

potassium blood test, as it has a good correlation with survival, except in cases of crushing injuries. One case of an avalanche survivor with 6.4 mmol/L potassium has been published. Serum potassium greater than 12 mmol/L (8 mmol/L in case of avalanche) is associated with extensive cell death and was associated with 100% mortality.[91] A case has been reported of a child with a serum potassium of 11.7 mmol/L, who survived without neurological consequences after accidental hypothermia by submersion.
  - If temperature is below 15 °C (or perhaps it is possible to survive up to 9 °C?), the diagnosis of death could be made, although it should be remembered that "a hypothermic person is never dead until they are warm and dead". Hypothermic people have been revived after 6.5 hours of CPR without neurological damage.
- Transfer to a hospital with extracorporeal circulation unit or extracorporeal oxygenation membrane, as this is the treatment of choice in these cases. A retrospective study of 32 patients with deep hypothermia and cardiac arrest has documented a 47% survival without consequences after extracorporeal circulation treatment.

MOST FREQUENT COMPLICATIONS

Due to hypothermia

- Arrhythmias while the core temperature is below 30-32 °C.
- Dehydration.
- Hyperkalaemia.
- Hyper or hypoglycaemia.
- Acid-base balance disorders.
- Clotting disorders.
- Aspiration pneumonia.
- Pulmonary oedema.
- Infections.
- Pancreatitis.
- Concomitant frostbite.

Due to treatment

- A drop in core body temperature (after drop) despite cold exposure having ceased and overheating shock (hypotension and shock with low cardiac output, so it is partly cardiogenic shock; myocardial damage is greater the longer it takes to rewarm the hypothermic person). These complications could be caused by the persistence of a thermal gradient between the hot body nucleus and the cold periphery (conduction) that has not yet had time to warm up; vasodilatation is not essential for such a relapse to occur. These complications can occur with any type of heating (passive and active external or internal). The presence of these complications does not necessarily indicate a poor prognosis, and no case of death or serious sequelae can be attributed to a temperature relapse.
- Acidosis from heating, due to the recirculation of lactic acid accumulated in the peripheral circulation.
- Burns caused by heat bags, which should be insulated with a cloth.
- Iatrogenic hyperthermia.
- Aspiration pneumonia.
- Pulmonary oedema.
- Infections.
- Pancreatitis.
- Peritonitis.
- Ventricular fibrillation.
- Gastrointestinal bleeding.
- Rhabdomyolysis, acute tubular necrosis, compartment syndrome.
- Thrombophlebitis.

PROGNOSIS

Consequence-free recovery has been reported after 190 minutes of extracorporeal rewarming and 390 minutes of ROSC and warming up with a heating blanket and peritoneal lavage. Survival of patients with grade IV hypothermia treated with extracorporeal circulation or extracorporeal oxygenation membrane is 47-63%; 37% without this treatment.[91]

6

FROSTBITE AND OTHER COLD-RELATED ILLNESSES

CONCEPT

Freezing injuries are frequently localised to the feet, hands and face (nose and ears) due to exposure to temperatures below 0 °C, generally below –3 °C.[106] In the mountains they are usually associated with hypoxia and dehydration.

EPIDEMIOLOGY

In our environment, 52% of the freeze-ups produced during sports practice correspond to mountaineering, 44% to skiing and 4% to free flying (hang-gliding and paragliding). 87% of those frozen are men and the average age is 27 years old.[89]

Figure 6.1. Climbing on ice.

PATHOPHYSIOLOGY

The pathophysiology of freezing is divided into 4 phases:

- Pre-freezing stage: cooling of the tissues with vasoconstriction and ischemia but without formation of ice crystals. Cooling and ischemia cause hyperesthesia or paraesthesia.
- Freezing and thawing stage: formation of intracellular (in quick freezes) and/or extracellular (in slow freezes) ice crystals that cause protein and lipid degradation, electrolyte disorders, cell dehydration, membrane lysis and cell death. Thawing can mediate the process of ischemia and reperfusion, as well as the inflammatory response.
- Vascular stasis stage: vessels undergo intermittent vasoconstriction, alternating with vasodilatation; blood may leak through them or clot inside them.
- Late stage ischemia: occurs from progressive ischemia and tissue infarction. It is due to a cascade of processes including inflammation triggered by thromboxane A_2, prostaglandin F_2-alpha, bradykinins and histamine; intermittent vasoconstriction of arterioles and veins; continuous reperfusion injury; dissemination of circulating microvascular emboli; and formation of thrombus in the great vessels.

The destruction of microcirculation is the main factor leading to cell death.

Tissue freezing is aggravated if it is refrozen after thawing.[107, 108]

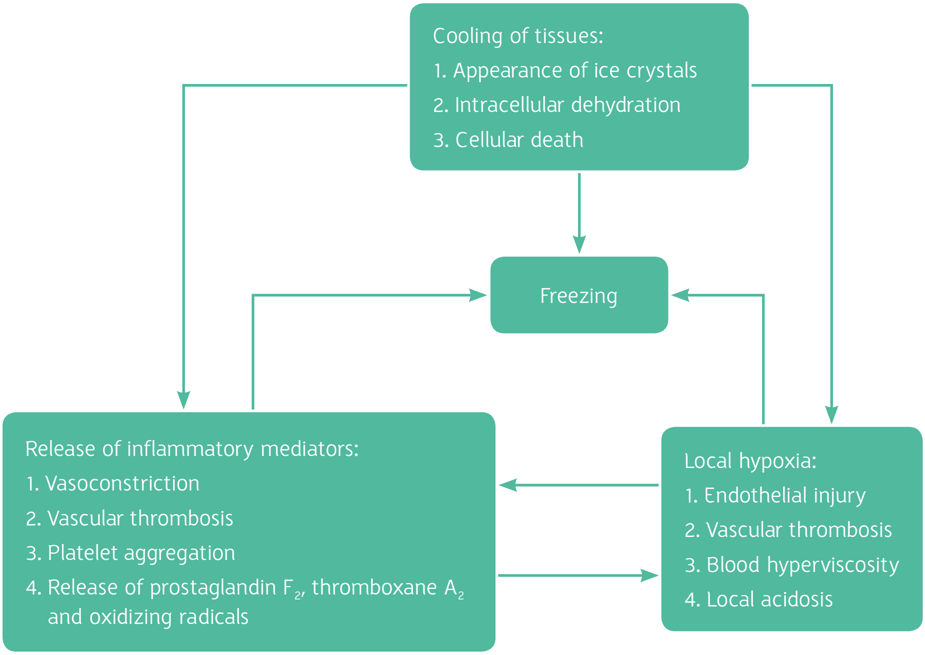

Cooling of tissues:
1. Appearance of ice crystals
2. Intracellular dehydration
3. Cellular death
Freezing
Release of inflammatory mediators:
1. Vasoconstriction
2. Vascular thrombosis
3. Platelet aggregation
4. Release of prostaglandin F2, thromboxane A2 and oxidizing radicals
Local hypoxia:
1. Endothelial injury
2. Vascular thrombosis
3. Blood hyperviscosity
4. Local acidosis

Figure 6.2. Pathophysiology of freezing.[109]

CLINICAL PRESENTATION

Classification

Typically, freezes have been classified as one of 4 degrees based on the physical and image-based examination after the rewarming.

Very shallow frostbite

First warning signal that may precede freezing. A cold sore is a cold injury due to intense vasoconstriction of exposed skin, usually on the cheeks, ears, or nose. Ice crystals form on the surface of the skin but not in the tissues. Numbness and pallor subside quickly when the skin is warmed. There are no sequelae, but after overheating, pain may appear and persist for days or weeks. There may also be a loss of sensation, increased sensitivity to cold and hyperhidrosis that may persist for years.

Superficial frostbites

First-degree frostbite. At first, a white or yellow, slightly elevated plaque appears on the area of the lesion. The skin then becomes erythematous and oedematous with decreased sensitivity. There is no skin infarction or blistering, but there may be a slight skin detachment.

Second-degree frostbite. Superficial vesicles appear and within 24 hours blisters appear with a clear or milky liquid containing the inflammatory mediator thromboxane A_2, surrounded by erythema and oedema. Sensitivity is decreased.

Deep frostbite injuries

Third-degree frostbite. Haemorrhagic blisters appear, indicating that the lesion has spread to the reticular dermis and below the vascular dermal plexus. In two weeks, the blisters turn into a black crust. Cyanosis is common.

Fourth-degree frostbite. No blisters, the lesion extends completely throughout the dermis and involves subcutaneous tissues, with necrosis extending to the muscles and bone level.

Several degrees of frostbite can coexist in the same limb.

Current pre-hospital classification[110]

Table 6.1. Initial frostbite classification

	First degree	Second degree	Third degree	Fourth degree
Initial spread of cyanosis after quick rewarming	Absence of cyanosis	Cyanosis in distal phalanx	Cyanosis in the middle or proximal phalanx	Cyanosis in the carpus or tarsus
Blisters on the second day	Absence of blisters	Clear blisters	Haemorrhagic blisters on fingers	Carpal or tarsal haemorrhagic blisters
Prognosis on the second day	No amputation No consequences	Soft tissue amputation	Amputation of the finger bone	Amputation of the limb bone

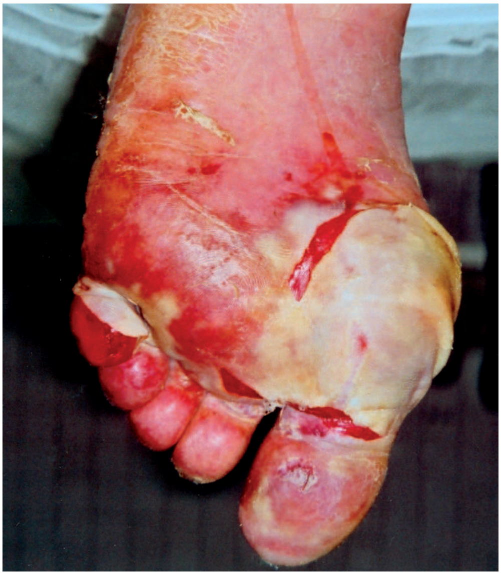


Figure 6.3. First-degree frostbite.

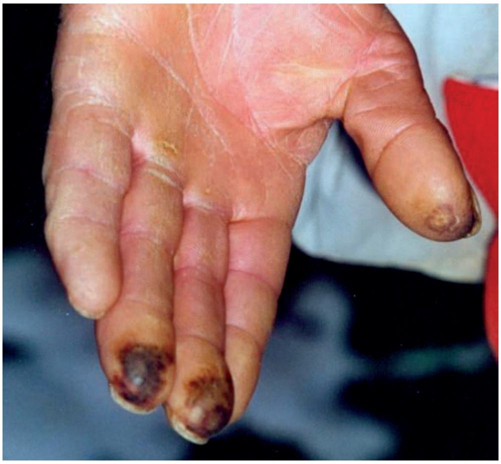


Figure 6.5. Third-degree frostbite.

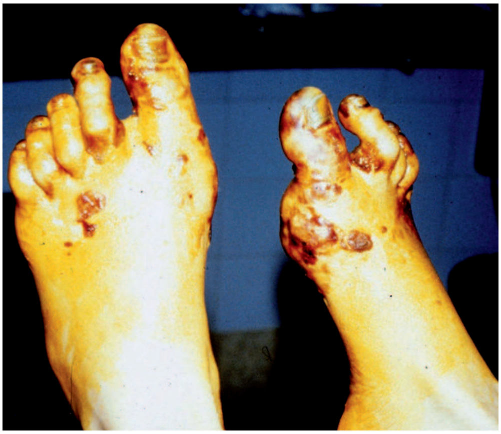


Figure 6.4. Second-degree frostbite.

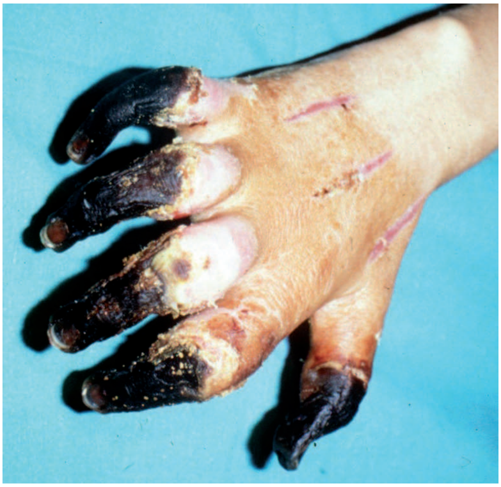


Figure 6.6. Fourth-degree frostbite.

The need for amputation correlates more with the duration of cold exposure than with temperature. If blood circulation is stopped for more than 6 hours, tissue injury will be permanent; if it is for more than 24 hours, the affected limb may be lost. Aside from prolonged exposure, tissue injury will be worse if it has cooled slowly and if rewarming has occurred slowly.

Prognostic factors

Table 6.2. Prognostic factors

Better prognosis	Worse prognosis
• Feeling of having pins and needles. • Skin elastic to pressure. • Normal colour. • Large blisters with clear fluid.	• Little dark blisters. • Haemorrhagic fluid. • Cyanosis. • Skin not elastic to pressure and apparently injured.

PREVENTION[111]

Conditions leading to frostbite and peripheral cold injury[112]

Freezing occurs when heat loss exceeds the ability of local tissue perfusion to deliver warm blood to the soft tissues. Therefore measures must be taken to minimise heat loss and maintain adequate tissue perfusion.

The main risk factors are temperature, wind and humidity.

Table 6.3. Risk factors for frostbite and peripheral cold injury

Environmental	Temperature Humidity Duration of exposure Cold wind Altitude Substances that remain liquid at temperatures of –40 °C: oil, lubricants, petroleum, alcohol, antifreeze Contact with metals or certain minerals
Mechanical	Tight clothing and boots Inadequate clothing and shelter
Physiological	Hypothermia Race: highest risk in black people Sex: women's fingers get cold before men's do Skin moisture Previous cold injury Trauma Erythroderma: burns, sunburn, psoriasis, ichthyosis, exfoliative dermatitis Hyperhidrosis Hypoxia Tobacco Energy deficit Poor physical fitness Hypotension Atherosclerosis Raynaud's syndrome
Vasospastic disorders	Diabetes Shock Vasoconstrictor drugs
Psychological	Severe mental stress

Primary prevention

Protection from cold (C)

- Avoid environmental conditions with high risk of frostbite (−15 °C even with low wind speed). Take the altitude into account, as the outside temperature decreases by 0.65 °C per every 100 m altitude (6.5 °C per 1,000 m).
- Protect the skin from moisture, wind and cold. Humidity can multiply the effect of cold by 14. The wind can multiply it by 10.
- Avoid perspiration or moisture in the extremities. Aluminium hydroxide powders used as antiperspirants may be helpful in keeping feet dry.
- Covering the body with several layers of suitable clothing, the air trapped between the various layers insulates the skin, protecting it from the cold.
- Ensure an adequate mental response to extreme environmental conditions (avoid drugs, alcohol or extreme hypoxaemia).
- Hand and foot chemical warmers and electric foot warmers may be used to maintain peripheral heat (warmers should be close to body temperature and not restrict blood flow if used inside a boot).
- Minimise the time of exposure to cold. A person buried under an avalanche cools down by 3 °C every hour.
- Be able to recognise symptoms and signs of frostbite for early action. A pale, clumsy and numb limb should be warmed up as soon as possible (e.g. by placing it under the armpits or on the abdomen of a partner).

Maintenance of peripheral perfusion (C)

- Maintain an adequate internal temperature and sufficient hydration.
- Minimise the effects of known diseases and/or medications or drugs that may decrease perfusion.
- Cover the skin and head to avoid vasoconstriction.
- Reduce the compression of blood flow by avoiding excessive compression of clothing and footwear (harness, boots, socks, rings, gloves) and immobility.
- Ensure adequate nutrition to guarantee sufficient energy intake.
- Use oxygen in hypoxic conditions (e.g. high altitudes).
- Exercise improves peripheral perfusion by producing peripheral vasodilatation; exhaustion should not occur, however, as fatigue aggravates heat loss **(B)**.
- Consider diseases and habits that could increase the risk of frostbite: previous freezes, infected wounds, diabetes, tobacco, alcohol.

Emollients do not protect from, or may even increase, the risk of frostbite.

Secondary prevention

- Protect frozen tissue from further damage.
- Remove rings and jewellery.
- Do not give alcohol or tobacco.
- Do not rub or apply snow or ice to avoid micro-injuries.
- Do not thaw until it can be guaranteed that it will not refreeze. The cycle of freezing and thawing produces the release of prostaglandins and thromboxane A_2 that promote vasoconstriction, platelet aggregation, thrombosis and cell injury **(B)**.
- Passive or spontaneous thawing should be allowed if rapid reheating cannot be achieved, as prolonging the duration of freezing increases morbidity **(C)**.

TREATMENT[85, 109, 111, 113-116]

In freezes there is a group of dead cells, a group of intact cells and a group of injured cells that may or may not heal depending on the treatment.

The curative treatment is based on:

- Reheating to stop the formation of ice crystals in the tissues.
- Reversing vasoconstriction to improve blood circulation and tissue oxygenation.
- Administering drugs to block chemical mediators of inflammation.

Prehospital treatment

There may be two situations: that the limb can be kept thawed if it is being warmed up, or that there is a risk of re-freezing.

Common treatment

- Treatment of hypothermia: mild hypothermia can be treated simultaneously with frostbite. Cases of moderate or severe hypothermia should be treated before frostbite **(C)**.
- Adequate oral hydration with hot sugary drinks, or by slow infusion of a warm physiological saline solution **(C)**.
- Low molecular weight dextran: decreases blood viscosity, preventing the formation of micro thrombi. There are no human studies that show their benefit in the treatment of frostbite. They may be given if the patient is not a candidate for other treatments (fibrinolysis) **(C)**.
- Ibuprofen: is a non-steroidal anti-inflammatory that blocks the arachidonic acid pathway, decreasing the production of prostaglandins and thromboxane that cause vasoconstriction, ischemia and tissue damage. Acetylsalicylic acid has been proposed as an alternative for its anti-inflammatory and antiplatelet effects. However, acetylsalicylic acid also blocks prostaglandins that are beneficial for healing lesions (PGE_1). There are no studies comparing ibuprofen and aspirin in frostbite. The recommended dose of ibuprofen would be 12 mg/kg/day divided into two doses with a maximum of 2,400 mg divided into 4 doses. Continue administration until the lesion has healed or surgery is performed (4-6 weeks) **(C)**.
- Acetylsalicylic acid 100-300 mg: its use is controversial as it blocks PGE_1 but it is usually administered as an antiplatelet agent.
- Dressings: there is no evidence of their beneficial effect. If used, apply dry gauze to the frozen area and between the fingers without affecting motility. Bandage without any pressure as this could cause oedema of the area **(C)**.
- Wandering and protection: although there is no evidence of beneficial effects, avoiding trauma to frozen limbs by protecting and immobilising them is recommended. The risk-benefit ratio should be assessed (e.g. if evacuation involves walking, it is reasonable to do so). After defrosting, the limb becomes oedematous, so keep in mind that if boots are removed, they may not fit again **(C)**.

Specific recommendations if there is no risk of refreezing

- Rapid rewarming: if the definitive treatment is expected to last more than 2 hours and it is possible to guarantee that the limb will not refreeze, heating is started by immersion in warm water at a constant temperature of 37-39 °C, avoiding other sources of heat due to the risk of thermal skin injury (fire, stove, etc.). If a thermometer is not available, the proper temperature is the temperature at which the hand can be immersed in water for 30 seconds without burning. Rewarming is maintained until the limb turns red or purplish and is soft and flexible to the touch, which usually takes about 30-60 minutes. It is then air-dried or gently dried to prevent further damage **(C)**.
- Antiseptic solution: Although there is no evidence of benefit, the addition of an antiseptic solution (chlorhexidine, povidone iodine) to the overheating water may reduce the risk of infection in the event of significant oedema **(C)**.
- Pain control: non-steroidal or opioid anti-inflammatory drugs **(C)**.
- Passive or spontaneous defrosting: if rapid warming is not possible, slow rewarming is attempted by taking the injured person to a warm place (shelter) and heating the limb with another person's body heat (armpit, abdomen) **(C)**.
- Blister debridement: It is better to not routinely debride in out-of-hospital care. Blisters of clear fluid contain prostaglan-

dins and thromboxane; if they are under tension with a high risk of rupture, they should be drained by aspiration with a needle and syringe, and a dry gauze dressing should be applied to minimise any infection. Haemorrhagic blisters must not be debrided. This recommendation is supported by little clinical evidence. Some authors claim that debridement of the blisters can dry out the exposed tissue and only recommend drainage if it interferes with limb movement or if there is a risk of infection **(C)**.

- Topical Aloe vera: reduces the formation of prostaglandins and thromboxane in superficial areas so it is placed on the defrosted tissue before applying dressings. It can be reapplied every time the dressings are changed or every 6 hours **(C)**.
- Limb elevation: If possible, elevate the limb to heart level so as to minimise swelling **(C)**.
- Oxygen: although there is no evidence, the recovery of thawed tissue depends on tissue oxygenation, so it is recommended to administer oxygen in case of hypoxia **(C)**.

Table 6.4. Prehospital treatment of frostbite (adapted from McIntosh)

Outpatient treatment
Treat hypothermia or severe trauma.
Remove rings and jewellery that may cause compression or trauma.
Do not rub. Allow to air dry.
Reheat quickly in water at 37-39 °C until the area is pink, soft and supple (about 30 minutes). Or rewarm passively if quick heating is not possible.
Give Ibuprofen 12 mg/kg/day divided into two doses.
Consider administering acetylsalicylic acid 100-300 mg as an antiplatelet agent.
Give analgesia if needed (opioids).
Protect from direct trauma and refreezing.
Apply topical Aloe vera cream or gel.
Apply dry dressings.
Elevate the limb.
Moisturise.
Avoid ambulation on the thawed limb, unless only the toes are affected.

Immediate hospital treatment

Treatment of hypothermia: as in prehospital treatment (above) **(C)** and add:

- Debridement of blisters: reassess.
- Systemic antibiotics: neither is frostbite a lesion prone to infection nor there is evidence to prove that post-freeze oedema is more susceptible to gram-positive infections. Therefore, there is no evidence to support routine preventative antibiotic administration. The administration of antibiotics is indicated if there are risk factors such as a major trauma or signs or symptoms of cellulitis or sepsis **(C)**.
- Anti-tetanus prophylaxis: according to standard recommendations **(C)**.
- Locoregional anaesthesia (freezing grade 2-4): produces analgesia and vasodilatation.
- Thrombolytic treatment (grade 4 freezes) to stop microvascular thrombosis. Intra-arterial or intravenous administration of tissue plasminogen activator (tPA) within 24 hours of thawing may restore some or all of the tissue at risk of ischemia.[117, 118] The risks of thrombolytic therapy are bleeding and compartment syndrome **(C)**.
- Heparin: is not recommended as a monotherapy, although it may be used as an adjuvant to thrombolysis.

- Vasodilator treatment with prostacyclin analogue PGI_2 Iloprost (freezing grade 2-4): effective in reducing the number of amputations beyond 48 h after reheating[113] **(C)**.

Table 6.5. Immediate hospital treatment of frostbite (adapted from McIntosh)

Immediate hospital treatment
As in the prehospital treatment + Anti-tetanus prophylaxis. Revaluate debridement. Systemic hydration. Consider thrombolysis in case of deep freezing with high potential morbidity if thawed less than 24 hours ago. Perform angiography prior to thrombolysis and to monitor the process. Consider vasodilator treatment with Iloprost. Perform angiography and/or technetium-99 scintigraphy to assess the impact of the lesion and evaluate with an expert surgeon regarding possible amputation.

Long-term treatment

Its purpose is to mitigate the aftereffects.

- Hydrotherapy: after thawing, baths are taken every 12-24 hours with water at 37-39 °C with the theoretical objective of improving circulation, eliminating surface bacteria and debriding the devitalised tissue. There is no evidence that hydrotherapy improves the outcome, but since it is not harmful it is usually done **(C)**.
- Hyperbaric oxygen: there are not enough data for its recommendation.
- Sympathectomy: in some studies, sympathectomy has reduced the duration of pain, although it has not reduced the extent of lost tissue. It may play a role in alleviating pain, paraesthesia and hyperhidrosis, but there are insufficient data for its recommendation.
- Hospitalisation: Initial treatment of deep freezes may be performed in a hospital setting **(C)**.
- Fasciotomy: thawing, by re-melting ischemic tissues, can develop a rise in compartmentalised tissue pressure. Compartment syndrome manifests itself as painful distension with reduced movement and sensation. If it does appear, it is urgent to evaluate the intracompartmental pressure and decompress it urgently if necessary to save the limb **(C)**.
- Surgical treatment and amputation: angiography, technetium-99 scintigraphy, or MRI may be helpful in delineating necrotic tissue. Clinical demarcation of viable and non-viable areas may take 1-3 months. If sepsis develops, amputation will quickly follow **(C)**.

EVOLUTION

The evolution of frostbite is usually as follows:

- Superficial first-degree frostbite: healing in 3-4 days with no consequences.
- Superficial second-degree frostbite: healing in 10-15 days with a few after-effects.
- Deep third-degree frostbite: healing in 21 days with after-effects.
- Deep fourth-degree frostbite: amputation after 2-3 weeks.

OTHER COLD-RELATED CONDITIONS

Trench foot

Exposure of wet feet to temperatures between 0 and 15 °C for more than 12 hours can result in an injury to the blood vessels of the skin and the sensitive nerves called trench foot.

First there are paraesthesia and punctures, then pain and erythema. The foot is swollen and numb, and impedes putting on footwear. Afterwards, blisters and ulcers may appear.

Finally, hypersensitivity to cold, itching, pain, swelling, numbness, and loss of sensation may appear and last for weeks or months.

Preventative application of antiperspirants containing aluminium hydroxide may decrease sweating.

Treatment involves wrapping the patient up and keeping the foot dry, clean, and elevated. Symptoms usually go away in less than 4 months. Carbamazepine (200 mg every 8 hours) may be used for neuritic-type pain.

Chilblains

They are similar but milder lesions, due to an exaggerated vasoconstriction caused by the cold that leads to cellular ischemia and oedema of the limbs. It produces erythematous plaques with swelling that sometimes progress into blisters and ulcers. They cause itching and sometimes pain. They mainly affect the legs, toes, hands and ears. They usually appear 24 hours after the exposure and last up to 3 weeks. The predisposing factors are: air temperature between 0.5 and 16 °C, wind and humidity. Prevention is based on staying dry (avoiding sweating) and warm. They are treated with heat and, if necessary, with a 1% hydrocortisone ointment.

Eye injury due to cold

This is a transient corneal injury with oedema and blurred vision that mainly affects cross-country skiers. It is more frequent in long distance sports with a global temperature below −15 °C and seems to be due to the inhibition of blinking. It recovers spontaneously within 24 hours.

Bronchoconstriction due to cold

It is seen in 4-20% of the general population and 11-50% of elite athletes. It is diagnosed by demonstrating a 10% decrease in the incidence of FEV_1, and the use of some type of scarf reduces its frequency. In some cases it requires treatment with bronchodilators.

Increased risk of ischemic heart disease

Cold weather increases sympathetic activity, peripheral resistance, mean blood pressure, cardiac work and oxygen demand, increasing the risk of angina in patients at risk.[119, 120]

7 HEAT, DRYNESS AND HUMIDITY

HEAT

Adaptation to heat

Heat illness occurs when the body gains or produces heat faster than it can remove it. Initially, the body attempts to remove heat by circulating blood from the centre of the body to the periphery. This is achieved by means of vasoconstriction in the kidneys and other viscera –allowing the central blood to be carried to the periphery– and peripheral vasodilatation –bringing the maximum amount of blood into contact with the skin, so that it can be cooled–. When this mechanism fails, a dangerous temperature increase occurs.

Production and regulation of heat

The body produces 2,000 to 5,000 kcal of heat per day, largely due to muscle activity. The body must remove this heat in order to prevent a dangerous increase in body temperature. Without thermoregulatory mechanisms, body temperature would increase by 1.1 °C per hour (for example, the temperature of a sedentary 70 kg person producing only 2,000 kcal per day would increase from 34.4 °C to 71.4 °C in 24 hours). This increase can be 15-20 times greater in case of intense exercise or high temperatures. This explains why cases of heat stroke have been observed due to intense exercise at moderate temperatures (13-28 °C).

The transfer of heat from the body to the environment and vice versa takes place via four mechanisms:

- Conduction.
- Convection.
- Radiation.
- Evaporation.

In warm environments, the main heat removal mechanisms are radiation and evaporation.

Blood heats up by capturing the heat produced through muscle activity and passing through the skin, releasing this heat into the atmosphere. When the air temperature is above 35 °C, radiation ceases and evaporation is the only useful cooling mechanism.

At rest, the sweating mechanism starts at an ambient temperature of 30-32 °C. The evaporation of 1 mL of sweat results in a loss of 0.58 kcal of heat, i.e. one litre of sweat results in the loss of 580 kcal of heat. Evaporative cooling is limited, as the maximum sweating of a person unacclimated to heat is approximately 1,500 cm^3 per hour. The evaporation of this amount of sweat is able to counteract the heat produced by running 10 km at a speed of 10 km per hour.

If you exercise in hot weather, you can easily lose 1-2 litres of fluid per hour and even lose 6-10% of your body weight.

The evaporation rate is inversely proportional to the relative humidity of the air; when the humidity is high, evaporation occurs more slowly and sweating becomes a less effective cooling mechanism. If the humidity is higher than 70-75%, evaporation is difficult and the body loses its ability to remove heat, leading to dangerous body temperatures.

The American Medical Society for Sports Medicine (AMSSM) advises cancelling athletics races when the wind chill (humidity corrected temperature) is above 28 °C.[121.]

Table 7.1. Humidex chart: perceived heat for each range of humidity

Temp.	Humidity																
	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20
43													56	54	51	49	47
42												56	54	52	50	48	46
41											56	54	52	50	48	46	44
40										57	54	52	51	49	47	44	43
39									56	54	53	41	49	47	45	43	41
38							57	56	54	52	51	49	47	46	43	42	40
37					58	57	55	53	51	50	49	47	45	43	42	40	
36			58	57	56	54	53	51	50	48	47	45	43	42	40	38	
35		58	57	56	54	52	51	49	48	47	45	43	42	41	38	37	
34	58	57	55	53	52	51	49	48	47	45	43	42	41	39	37	36	
33	55	54	52	51	50	48	47	46	44	43	42	40	38	37	36	34	
32	52	51	50	49	47	46	45	43	42	41	39	38	37	36	34	33	
31	50	49	48	46	45	44	43	41	40	39	38	36	35	34	33	31	
30	48	47	46	44	43	42	41	40	38	37	36	35	34	33	31	31	
29	46	45	44	43	42	41	39	38	37	36	34	33	32	31	30		
28	43	42	41	41	39	38	37	36	35	34	33	32	31	29	28		
27	41	40	39	38	37	36	35	34	33	32	31	30	29	28	28		
26	39	38	37	36	35	34	33	32	31	31	29	28	28	27			
25	37	36	35	34	33	33	32	31	30	29	28	27	27	26			
24	35	34	33	33	32	31	30	29	28	28	27	26	26	25			
23	33	32	32	31	30	29	28	27	27	26	25	24	23				
22	31	29	29	28	28	27	26	26	24	24	23	23					
21	29	29	28	27	27	26	26	24	24	23	23	22					

Acclimatisation to exercise in hot environments

It is possible to acclimatise to heat by practicing physical exercise in a hot environment for 1-2 hours a day for 10-14 days. Acclimatisation persists for more than one month[121] **(B)**. Exercise should be performed at an intensity of 60-70% and the athlete should be protected from heat, drink plenty of fluids, and be alert for any symptoms of heat stroke. Cardiovascular changes occur during the first 3-5 days, and those related to sweating mechanisms occur within 10 days. Heat acclimation reduces the use of muscle glycogen by up to 50-60%, reducing fatigue. Furthermore, the loss of salt due to sweating, which in the non-acclimated individual is 15-30 g/day, is reduced in the acclimated individual to 3-5 g/day, reducing the possibility of heat cramps

Heat cramps[122 123]

Concept

Heat cramps are spasmodic muscle contractions, usually of the legs, that can last 15 minutes or more. They are possibly due to changes in the excitability of motor neurons[124].

Risk factors include exercise-induced muscle fatigue, dehydration, and loss of sodium from excessive sweating.[121]

They can be prevented by drinking plenty of salt-containing liquids.

Treatment (C)

- Muscle stretching.
- Intake of salty liquids.
- Physiological saline solution.
- Refractory muscle cramps may be improved with intravenous benzodiazepines.

Heat syncope[122, 123]

Concept

Syncope is a loss of consciousness, which in this case is due to the loss of minerals and dehydration that accompanies excessive sweating. In an effort to increase heat loss, the blood vessels in the skin dilate to such an extent that they collect a large amount of blood inside, causing a decrease in the amount of blood reaching the brain and a loss of consciousness.

Signs and symptoms

- Extreme fatigue, wheezing, dizziness, vomiting and fainting.
- Cold and clammy or hot and dry skin, hypotension, weak and rapid pulse.

Treatment (C)

- Rest in a cool place in a horizontal position or with the feet elevated to reduce oedema.
- If conscious: administer salt water (dilute a tablespoon of salt in one litre of water).
- If unconscious: saline infusion. If dehydration is severe, you may easily need more than 4 litres of serum.
- If left untreated, it can degenerate into heat stroke.

Effort-related heat exhaustion and heat stroke[122, 123]

Concept

Heat exhaustion is often associated with dehydration **(B)**.

Heat stroke is an increase in body temperature due to a failure of thermoregulation. It is an acute process with hyperthermia due to dehydration. It occurs when the body is unable to remove heat produced either by environmental conditions, or by the body itself. In athletes the three main causes are high intensity exercise, high ambient temperature and high relative humidity. When the thermoregulatory mechanisms fail, this process progresses to extreme and life-threatening hyperthermia.

Hyperthermia can lead to brain swelling and increased intracranial pressure that, combined with lower blood pressure, reduces the amount of blood reaching the brain. At the same time the body's proteins are denatured and tissue damage occurs.

Signs and symptoms

Heat stroke is characterised by a core temperature above 40 °C associated with changes in the central nervous system and multi-organ

Table 7.2. Clinical assessment of heat exhaustion and heat stroke.

Heat exhaustion	Heat stroke
Symptoms reminiscent of a viral infection: • Fatigue and weakness. • Intense thirst. • Dizziness. • Nausea and vomiting. • Headache. • Muscle pain, cramps. • Irritability. • Sweating. • Piloerection (goosebumps). • Tachycardia • Tachypnea. • Hypotension. • High temperature but below 40 ºC.	• Same symptoms as heat stroke. • Central nervous system dysfunction in 80% of cases: strange behaviour, hallucinations, mental state disorders, confusion, disorientation, coma. Loss of consciousness may occur without prior symptoms. • Sweating may be present in heat stroke caused by exercise, but is most often absent (anhidrosis) in classic heat stroke. • Rectal temperature >40 °C, axillary temperature is not as useful. • Tachycardia (>130), hypotension. • Clotting disorders: purpura, conjunctival haemorrhage, melena, haemorrhage, haemoptysis and haematuria. • Tachypnea. • Oligoanuria. • Complementary explorations in hospital: – Laboratory tests: hypernatremia and leucocytosis due to hypertonic dehydration, hypokalaemia in the first phase and hyperkalaemia when renal failure occurs. – ECG: changes in ST, inverted T and conduction disorders. Heat stroke can simulate an acute myocardial infarction.

failure, which should raise the alarm about this pathology **(B)** (see Table 7.2).[125]

Warning symptoms suggesting heat stroke include, early and persistent muscle cramps, abdominal pain, nausea, and behavioural disorders (confusion, clumsiness, disorientation, agitation, headache) **(B)**[121]

Then neurological disorders appear (numbness, stupor, coma, convulsions, loss of muscle tone with contractures and pupillary alterations), cardiocirculatory disorders (tachycardia over 130 beats per minute, hypotension), tachypnea, hot skin, core temperature is usually higher than 40.1 °C. Petechiae purpura, mucosal haemorrhages and epistaxis appear. Symptoms may appear the night after sun exposure. Kidney failure may occur in 25-30% of patients with hypotension or shock. Mortality rate is 30-50%.

Prevention[121-123]

Table 7.3. Risk factors for heat stroke

- Obesity
- Poor physical fitness
- Poor heat acclimatisation
- Dehydration
- Previous history of heat stroke
- Sleep deprivation
- Sweat gland dysfunction
- Sunburn
- Viriasis
- Diarrhoea
- Drug and drug use: alcohol, amphetamines, antihistamines, benzodiazepines, cocaine, diuretics, clopidogrel and laxatives.

Preventative measures:

- Avoid risk factors **(A)**.
- Acclimatisation: exercising for 10-14 days improves acclimatisation and reduces the risk of heat stroke **(C)**.
- Ensure hydration before activity and rehydrate periodically to prevent weight loss >2% **(B)**.
- Know the heat index before doing the activity **(A)**.
- Adapt physical activity to heat, reducing it or resting completely; take shelter in a cool, shaded place **(B)**.
- Wear clothing that promotes heat loss by evaporation, convection, conduction or radiation **(B)**.

Wear light clothing and stay in a cool environment. Protect the head from the sun with a light hat, preferably made of cotton, as many synthetic fabrics allow ultraviolet radiation to pass through (remember that fog and clouds do not block the passage of such radiation). A common cause of heat stroke is a lack of head protection.

- Spraying water on the body during exercise is not helpful to counteract the heat produced by vigorous exercise for 30 minutes in hot weather. In addition, wetting clothes and shoes increases the chance of chafing and blistering.

When exercising in a hot environment, if you suddenly feel cold and have goosebumps stop exercising, go to a cool place and drink plenty of cold fluids, because the thermoregulatory system has become confused and it believes that it is necessary to increase your body temperature even more. If left untreated, this can lead to heat stroke and death.

Treatment[121, 122, 126-128]

In the hyperthermic patient, rectal temperature measurement is considered the option of choice **(A)**.

Refrigeration

Chill without delay, until reaching a temperature below 39 °C, and evacuate quickly to hospital.

Immersion in cold water is the method that most rapidly cools the body (0.15-0.24 °C/min) achieving the lowest mortality and morbidity, although it can be unpleasant for the conscious patient **(A)**.[130]

Some authors do not recommend immersion in cold water because from a physiopathological point of view they think that, it can cause peripheral vasoconstriction with a paradoxical increase in core temperature due to the contribution of hot peripheral blood to the central zone, it can induce the appearance of shivering, with an increase in temperature, and it can make it difficult to monitor the patients and their care.

A review of the medical literature does not provide evidence that there is an increase in core temperature with this method and, on the other hand, the shivering can be treated with benzodiazepines. Neuroleptics, such as chlorpromazine, are no longer used because of their adverse effects: seizure threshold reduction, interference with thermoregulation, hypotension, liver toxicity, etc.

Table 7.4. Cooling rate according to water temperature

Water temperature	Cooling
2 °C (35.6 °F)	0.35 °C/min
8 °C	0.19 °C/min
14 °C	0.15 °C/min
20 °C	0.19 °C/min

When immersion in water is not available, undress the patient, lay the person on their side in the foetal position to obtain the maximum evaporative surface area, spray with water at 15 °C and apply hot air at 45-48 °C to favour evaporative cooling. This can cool by 0.06 °C/min. The heat absorbed by the evaporation of 100 cc of water can lower the temperature by 1 °C **(B)**.

Another method is the application of ice water towels (0.12-0.16 °C/min) combined with ice packs on the head, trunk and extremities (0.04-0.08 °C/min); this is an effective, but slower means of cooling **(C)**.

In the case of air rescue, the downdraught produced by the helicopter rotor blades has been successfully used as a cooling method.

Once the temperature has reached 38.5 °C, refrigeration should be discontinued to avoid hypothermia. **(A)**.

Additional treatment

Treating dehydration: perfusing a saline solution improves renal blood flow and protects the kidneys from rhabdomyolysis, while also improving tissue perfusion in all organs to optimise heat exchange, oxygenation and the elimination of waste products. Start hydrating with an initial saline solution infusion of 1,000 mL and continue as necessary **(A)**.

Treat hypoxia, hypoglycaemia, and hydro-electrolyte disorders if needed.

Treat seizures caused by heat-induced brain dysfunction with benzodiazepines (diazepam 5-10 mg IV). Phenytoin is not helpful in this situation.[126]

There is evidence that administration of Dantrolene is not helpful in heat stroke **(A)**, although it may be effective in people with a genetic predisposition to malignant hyperthermia.[131-133]

Antipyretics are not used for heat stroke as they interrupt the hypothalamic adjustment caused by pyrogens and can lead to liver, haematological and renal complications. **(B)**

Treating rhabdomyolysis:

- Intravenous infusion of large amounts of fluids to achieve a urine output of 3 mL/kg/hour (may require up to 10 litres).
- Alkalinisation of the urine to achieve a urinary pH of 7.5-8 to prevent myoglobin precipitation in the renal tubules and to control the acidosis and hyperkalaemia associated with massive muscle necrosis. Although the clinical evidence is insufficient, it is usually insufficient in patients with CPK >6,000 IU/L.[134, 135]
- Mannitol infusion (0.25 mg/kg) to improve renal blood flow and glomerular filtration rate, increase urine output, and prevent fluid accumulation in the interstitial compartment through its osmotic action. Clinical evidence is insufficient.[134]

Furosemide may produce tubular acidosis, promoting myoglobin precipitation in the renal tubules.

If kidney failure occurs, dialysis should be considered.

Table 7.5. Heat stroke treatment

Heat stroke treatment
• Chill to a temperature of 38,5 °C • Treat dehydration. • Treat hypoxia, hypoglycaemia, and hydro-electrolyte disorders. • Treat seizures with benzodiazepines. • Treat rhabdomyolysis.

Disseminated intravascular coagulation may occur within 24 to 72 hours after admission. Liver function and muscle enzymes should be monitored for the first 5 days.

Loss of consciousness for more than 2-4 hours and a rectal temperature above 42.2 °C are signs of poor prognosis.

Mortality is proportional to the time between the rise in core temperature and the start of refrigeration. If treatment is delayed for more than two hours, mortality can reach 21-70%. Heat exhaustion is one of the few medical emergencies where a delay of a few minutes can significantly change the prognosis.

DRYNESS

The comfort zone is between 40 and 60% relative humidity: in this normal environment, 1-1.5 litres/day are lost. A drop in relative humidity below 30% can lead to dehydration with hydro electrolyte losses. Water loss can be as high as 7 litres.

Air humidity drops with altitude due to the drop in temperature: at 20 °C there are 150 g of water in 1 kg of air, while at –20 °C there are only 7.8 g.

The correct replenishment of water must ensure a daily amount of urine in excess of one litre, but even so, local dehydration (skin, respiratory mucosa and conjunctiva) cannot be compensated for. Dry skin is itchy. Dry respiratory mucous membranes cause thirst, hoarseness and retrosternal pain. The conjunctival dryness produces a stinging sensation.

HIGH HUMIDITY

An increase in relative humidity above 70-75% can compromise sweat evaporation. Heat exhaustion is more frequent in environments with more than 90% humidity. There is also discomfort and poor psychomotor performance. The skin loses its acid mantle, which favours the appearance of fungi (mycosis) and infection of the skin's hair roots (folliculitis).

8 SOLAR RADIATION

Sunlight allows us to see, has antidepressant properties, a certain bactericidal action and is essential for the synthesis of vitamin D_3 (anti-rachitic). The synthesis requirement for this vitamin is fulfilled by the irradiation of 20 cm^2 of skin (a surface smaller than the face) for 30 minutes a day.

Adverse effects of sun exposure are divided into acute and chronic. Acute symptoms include erythema solare, sunburn, immunosuppression and most skin diseases caused or triggered by the sun. Chronic conditions include skin ageing and skin cancer.

SUN AND THE SKIN

Injuries produced by the sun

The sun emits a large number of photons that travel as waves (radiation). Three types of radiation reach the Earth:

- Infrared radiation: representing 50% of the total and is responsible for the heat effect of the sun, its wavelength is longer than 760 nm.
- Visible light: representing 45% of the total and is the only one that is seen because it has a luminous effect; its wavelength is between 400 and 760 nm.
- Ultraviolet radiation: its wavelength is less than 400 nm and it only represents 5% of the total, but it has a biological effect.

The ultraviolet radiation that reaches the Earth is measured by the UVI index. Its values range from 0 to 16. The maximum can be reached at the equator, whereas in Europe it is usually no higher than level 8.

Sunburn is caused by excessive exposure to ultraviolet (UV) rays, which in turn are divided into UVA (320-400 nm), UVB (290-320 nm) and UVC (200-290 nm). UVC radiation is filtered and absorbed by the ozone layer before it can reach sea level. UVB is more potent than UVA and represent the main cause of sunburn (85%), but it only penetrates the skin by a small distance. On the other hand, UVA radiation represents the majority of the ultraviolet rays that reach the earth's surface (90% at midday) and, given that between 30 and 50% of these rays penetrate deep into the dermis, they are responsible for much of the acute and chronic ultraviolet skin effects, such as collagen degeneration, with its consequent early skin ageing.

To quantify the degree of sun protection, the MED and SPF systems are used.

- The MED (Minimal Erythema Dose) is the minimum exposure time that causes redness. This time multiplied by four produces first-degree burns and by eight, second-degree burns. Individuals can be classified into different phototypes according to their MED (Table 8.1).
- The SPF (Sun Protection Factor) number of a product indicates how many times an individual's MED is lengthened. For example, if an individual with a 6-minute MED uses a sunscreen with a sun protection factor of 10, he or she can tolerate a 60-minute exposure (6x10) without getting burned.

A **sun erythema** is the reddening of the skin caused by ultraviolet and infrared rays and is equivalent to a first-degree burn. Already detectable in the first 30 minutes of UV exposure, it is well developed in 2-6 hours, with a peak at 12-24 hours, and resolves in 4-7 days. May cause oedema, hypersensitivity and pain in exposed areas.

Table 8.1. Phototypes

Phototype	Skin description	Characteristics	DEM	Minim. SPF
I	Always burns, never pigments.	Light skin, light eyes, blond or red hair.	15-30 mJ/cm^2	≥ 15
II	Always burns and pigments slightly.	Clear skin, blue eyes.	25-40 mJ/cm^2	≥ 15
III	Rarely burns and pigments gradually.	Dark skinned Caucasians.	30-50 mJ/cm^2	10-15
IV	Never burns and always pigments.	Discreetly dark, Mediterranean skin.	40-60 mJ/cm^2	6-10
V	Brown skinned ethnic groups.	Brown skin, Indigenous peoples of South America.	60-90 mJ/cm^2	4-6
VI	Black skinned ethnic groups.	Dark skin.	90-150 mJ/cm^2	No

Sunburn is caused by UV rays and appears 4-6 hours after exposure. It equates to a second-degree burn. It causes blistering, pain, and decreased sensation, and may be accompanied by fever, chills, and nausea. Blistering sunburn doubles the risk of developing a malignant melanoma.

Sun and skin cancer

Chronic exposure to the sun can cause premature skin aging, premalignant lesions or malignant skin tumours. People with phototypes I and II are more likely to develop skin cancer the younger they begin to be exposed to the sun. UVB radiation plays an important role in the production of skin cancer, but UVA rays are also partly responsible, so a person who receives more than 10 sessions of UVA rays a year has an increased risk of developing skin cancer.

Regarding the risk of skin cancer, squamous carcinoma is associated with cumulative exposure to sun radiation and occurs most frequently in the most sun-exposed areas (face, back of hands, forearms), while melanoma is associated with sunburn, or intense, intermittent exposure to sunlight, and occurs most often in areas sporadically exposed to the sun (back, legs). The risk is higher in children, and five or more severe burns in adolescence double the risk of melanoma.[136]

Daily use of a protective sunscreen factor 15 or higher could reduce the occurrence of actinic keratosis by up to 40% and the occurrence of squamous carcinoma of the skin by up to 25%. There is insufficient evidence for the prevention of basal cell carcinoma **(B)**.[137, 138] Sporadic use can reduce the occurrence of actinic keratosis by 24%.

With respect to melanoma, the prevention of sunburn prevents its appearance, but it has not yet been shown that the use of sunscreens has a protective effect, as it is often used to prolong exposure to solar radiation, thus favouring the appearance of sunburn.[139-142]

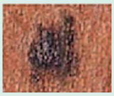
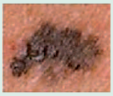
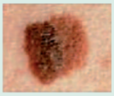
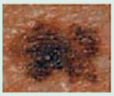
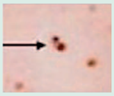
Its use may be protective if not used to prolong sunbathing.[143]

An asymmetrical lesion, with irregular edges, that has changed colour and is larger than 6 mm in diameter may be a melanoma.

Factors involved in sun injury

- Wavelength: UVB produces 1,000 times more erythema than UVA.
- Skin pigmentation: the more pigmentation, the fewer burns.
- Thickness of the skin.

Figure 8.1. A-B-C-D-E criteria to determine skin lesion malignancy

Asymmetry: when dividing the mole in two, the parts are different		**Asymmetry**: asymmetric
Border: when poorly defined, fuzzy, irregular and jagged		**Border:** Jagged outline
Colour: when you have colour changes, darkening, loss of colour, or multiple colours.		**Colour:** non-homogeneous colour
Diameter: when it has a diameter greater than 6 mm.		**Diameter**: more than 6 mm.
Evolution: changing over time such as growing, itching, bleeding, a sore that does not heal, etc.		**Evolution**

- Moisturizing: UV penetration is higher in damp skin than in dry skin.
- Anatomy: MED is higher in extremities than in the face, neck and trunk.
- Environmental reflection: approximately 80-90% of light is reflected by fresh snow, 60% by old snow, 25% by ice, 20-30% by water, 17-20% by sand, 3% by grass and 2% by asphalt. Clouds only reduce UVB radiation by 20%.
- Altitude: UV rays increase by 3% every 100 m to 2,000 m; from this altitude the increase is more rapid. In summer the level of irradiation at 1,500 m is twice that at sea level and in winter it is four times.
- Latitude: exposure is greater at low latitudes, nearer the Equator.
- Time of the day: 65% of UV rays reach the Earth between 10 a.m. and 4 p.m.

Prevention

- Avoid exposure during peak irradiation hours (10-16 hours).
- Protect yourself with suitable clothing: cap, visor, long-sleeved shirt, long trousers, etc.
- Keep in mind that the higher the altitude, the greater the radiation intensity (10% per 1,000 m), since the Sun's rays are less filtered by the atmosphere.
- Take into account the existence of surfaces that may reflect incident radiation: snow (85%), sand (35%), water (20%), cultivated soil (15%).
- Keep in mind that the lower the latitude, the greater the irradiation, as the sun's rays are more vertical.
- With respect to UVB radiation, factor 15 sunscreens filter 93% and factor 30 filters 97%. The protection against UVA radiation is superior with high protection filters. We recommend the use of filters with a factor of 15 or higher **(B)**, and in sufficient quantity (2 mg / cm^2 of skin). Apply to dry skin 15-30 minutes before exposure and renew after 20 minutes and if possible every two hours and after swimming or sweating. Use water-resistant creams (water, sweat); the water-resistant ones retain their properties after 40 minutes of immersion in water, and the water-proof ones, up to 80 minutes.[144]
- Use a protective lipstick.
- Avoid artificial tanning salons, as the UVA light they emit causes premature skin aging and skin cancer.
- Do not use tanning creams, as they intensify ultraviolet radiation.

Table 8.2. Required sun protection factor according to phototype and UV radiation index

UVI	Phototype			
	I	II	III	IV
1-3	>15	15-20	15-20	15-20
4-6	30-50	30-50	15-30	15-30
7-9	>50	30-50	30-50	30
>10	>50	>50	50	30-50

Treatment (C)[145]

If a burn has occurred, the use of damp compresses or moisturising ointments may relieve discomfort. A 0.1% diclofenac gel may accelerate the improvement of pain and erythema.

Topical steroid ointments provide little or no benefit and anaesthetic ointments may produce sensitisation and are therefore discouraged.

Pain and swelling may be treated with aspirin (500 mg every 6-8 hours), ibuprofen (400-600 mg every 6-8 hours), or acetaminophen (1 g every 8 hours).

The burn will resolve itself in 4-7 days.

SUN AND THE EYES

Ultraviolet radiation is absorbed by the cornea and can damage the eye. Conjunctivitis and decreased vision or blindness can occur; almost always temporarily. Snow ophthalmia is a superficial keratoconjunctivitis caused by a UVB sunburn. At 4-12 hours after exposure, conjunctival redness, intense photophobia, tearing, eye itching and intense pain appear. Chronic exposure to unprotected sunlight can cause cataracts.

Prevention

To increase safety in outdoor sports and to prevent eye injuries due to solar radiation, sunglasses and goggles should be worn.

In order to choose the right type of lens, it is important to know what protection they offer:

Each glass has a filter category (value assigned by the CE standard: EN 1836) that indicates the percentage of visible light transmitted to the eye. The higher the value, the more light the glass absorbs and therefore the less light it lets through to the eye. In the high mountains and snow, category 4 is recommended, but it should be remembered that the glasses of this category are not recommended for driving. There are photochromic crystals that darken or lighten depending on the intensity of the light and can pass from category 2 to 4 in less than a minute.

Table 8.3. Filter category and percentage of light filtration

Filter category	Percentage of light that the glasses allow to pass
0	80 – 100%
1	43 – 80%
2	18 – 43%
3	8 – 18%
4	3 – 8%

Regarding the colour of the crystals, yellow improves visibility in snowy areas with overcast skies, chestnut is recommended for nearsighted people and grey for farsighted people. However, the most important thing is not the colour, but the protection offered against radiation, and a light or dark coloured glass does not influence its filtering capacity. Dark crystals reduce the discomfort of glare but also reduce pupillary accommodation, and if they have no filter, they do not prevent radiation from passing through the pupil to the retina.

It is advisable to choose glasses with side shields that prevent the passage of radiation through this area.

Some crystals have a specific treatment that adds protection in certain circumstances:

- Anti-fog, which prevents the formation of mist.

- Water-repellent, which increases the water sliding on the glass, improving visibility.
- Anti-glare, which allows the reflection of excess light and increases visual comfort, and is achieved by means of polarising lenses to reduce the blinding effect, redefine contrasts and restore colour.
- Anti-scratch.
- Break-resistant.

In conclusion, for high mountain and snowy terrain outdoor activities, we recommend the use of glasses and goggles that have lenses with a category 4 filter, if possible with the option of having lenses with a category 3 filter. It is also advisable that they have an anti-fog treatment that improves the vision in case of fogging, and that they are resistant to scratches and breakages.

In case of losing the glasses, an effective alternative is the Eskimo method of making glasses with opaque material (chocolate foil, cotton handkerchief, sock) by making some cuts as a grille that allows vision and reduces light and ultraviolet radiation, thus avoiding the risk of conjunctivitis and actinic retinopathy. These opaque glasses offer superior protection over dark glasses with untreated lenses.

Rubbing the cheekbones, eyelids and nasal sidewalls with soap lessens the reflected light from these areas, reducing the amount of light that reaches the eyes.

Wearing a hat with a peak reduces exposure by 50%.

Neoprene face masks used for extreme cold are also useful for solar radiation.

Treatment (B)[146-148]

- Irrigate eyes with water or saline solution.
- Ibuprofen (400-600 mg every 6-8 hours) or acetaminophen (500 mg every 6-8 hours) may be given for pain.
- In the mountains, the use of eye drops containing atropine should be avoided as it dilates the pupil and ultraviolet radiation penetrates further into the retina, aggravating the lesion.
- Ultraviolet inflammation of the cornea usually resolves within 24-76 hours.
- Sometimes cycloplegics and topical antibiotics are required **(C)**.

9 FULGURATION

LIGHTNING

The cumulonimbus (Cb) is a very dense cloud with a wide, flat and dark base, accompanied by a great vertical cumuliform development that resembles the shape of a snowy mountain. It indicates the occurrence of storms. The storm is the last phase in the development of cumulonimbus, the moment when it explodes. Lightning is an electrical discharge from the cloud to the ground that occurs during a storm.

First you see the lightning and then you hear the thunder, as light travels at 300,000 km/sec and sound at 333 m/sec.

Assuming that the time between lightning and thunder is 10 seconds, the main core of the storm is more than 3 kilometres away (333 × 10 = 3,330 m). It can be calculated more easily by dividing the elapsed time in seconds by three, which gives the distance of the storm in kilometres.

A buzzing or hissing in the air and your hair standing on end herald an imminent lightning bolt.

The bolt is characterised by:

- High voltage (200-2,000 million volts of direct current).
- Very short duration.
- Strong heat production diffused to 80% of the body surface.
- Explosive force produced by the shock wave, causing associated traumas.

Figure 9.1. Lightning.

FULGURATION

The mountaineer may be affected by the direct impact of a lightning strike or by its irradiation. Mortality is 8-70%. In Spain, an average of 10-12 people die each year from lightning strikes.

Symptoms and signs[149]

Basically, the bolt of lightning produces neurological effect on three levels:

- Brain: neurocognitive and personality changes, sleep disorders, headache or attention deficit.
- Autonomic nervous system: regulation of blood pressure and cardiac response, gastrointestinal disorders, impotence or pain.
- Peripheral nervous system: sensitivity disorders and chronic pain.
- Keunoparalysis is a transient paralysis secondary to the impact of lightning associated with extreme vasoconstriction and sensory disorders of one or more limbs that usually resolves spontaneously within hours.

Minor forms

The injured person is conscious, sometimes confused, with amnesia that can last from 2 to 5 days. There may be blindness or transient deafness, tingling in the extremities, painless superficial burns, and shock wave trauma. The evolution is almost always favourable.

Moderate forms

The injured person is disoriented, may suffer from paralysis of the extremities, pale skin and a weak pulse due to hypotension. There are first and second degree burns at the current inlet and outlet points.

Serious forms

Cardiac arrest or ventricular fibrillation.

Localised injuries

Eye injury — cataracts may appear as late as two years later.

Hearing damage: more than 50% of cases have a tympanic perforation with deafness, dizziness, and nausea.

Table 9.1. Injuries found on victims of a lightning strike

- Memory loss (52%).
- Sleep disturbances (44%).
- Vertigo (38%).
- Numbness (36%).
- Joint stiffness (35%).
- Photosensitivity (34%).
- Muscle spasms (34%).
- Burns (32%).
- Headache (32%).
- Coordination problems (28%).
- Decrease or loss of hearing (25%).

Prevention[150 151]

Risk factors

The risk factors for being struck by lightning are the isolation and height of the individual. Therefore, the following positions are particularly dangerous: being near a tall object (tree, antenna, etc.) or being the tallest object in the area; being near water (swimming pool, beach, dock, river, etc.) and being near pipes or cables inside a building.

Wet clothing and footwear do not increase the risk of being struck by lightning unless they increase the individual's height, but if struck by lightning they can worsen burns and the chances of survival.

Although metals conduct electrical energy, they do not especially attract lightning, although they do make the burn worse. The same is true for mobile phones, unlike landline phones.

Preventive measures

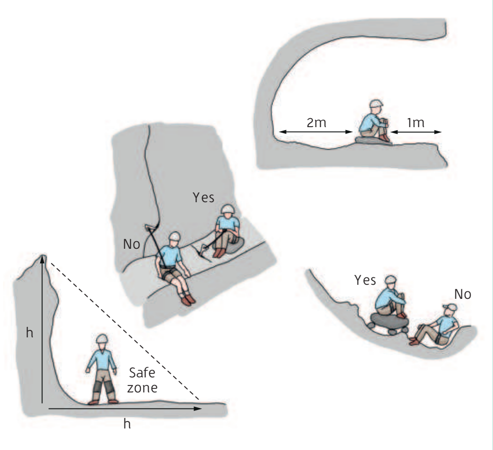


Figure 9.2. Protection from lightning.

Avoid the storm before it arrives

- Consult the weather forecast.
- A barometer can help predict weather changes. Forecasts according to barometer data (1 hPa = 100 m):
  - If in good weather there is a regular decrease of 10-15 hPa in 24 h, a disturbance is expected. If a drop of 1.8-2.5 hPa is observed in 3 hours, winds of 35 km/h can occur; if the drop is 3 hPa in 3 hours, winds of 60 km/h can occur, and if it drops 3 hPa in 1 hour, there is an imminent risk of storm.
  - If, in bad weather, a regular rise of 10-15 hPa is observed within 24 hPa, a return to good weather is expected. If there is a rapid rise of 3 hPa in 1 hour, strong winds can be expected.
- Calculate the distance of the storm: count the seconds between the lightning and the thunder (speed of sound: 330 m/sec) and divide by 3 to obtain the distance in kilometres. The speed of storm movement is usually 30-40 km/h.

- Lightning can even strike 10 km in front of the storm front. The possibility of being struck by lightning varies according to the distance:
    - 5-8 km from the storm: high possibility.
    - 10-16 km from the storm (thunder is heard): minor possibility.
    - At 24 km (you can see the lightning): very low possibility.
- The times of greatest risk are the beginning and end of the storm, as the victim underestimates the danger.
- When air is subjected to high electrical pressure, it becomes ionised and conductive, giving off a characteristic ozone smell.
- Hair standing on end and a buzzing sound similar to that of bees may indicate an impending discharge.

Avoiding the direct impact and ground currents spreading out through of the earth

- Avoid edges and peaks **(C)**.
- Hurry but do not run, as the airflow caused by speed can channel a flow of electricity.
- The radiating ground currents of the lightning follow the lines of least electrical resistance, such as cracks, channels and wet areas.
- The safest position is to sit or squat with knees and feet together to create a single point of contact with the floor. If you are standing, keep your feet together. If you are sitting down, lift your feet off the floor. If possible be on dry insulating objects: rope, mat, backpack, etc. **(C)**.
- It is recommended to seek protection inside a deep cave, a dense forest or a deep ravine. Shallow caves, lonely trees, open shelters or tents offer no protection. Huts, etc., do not protect against lightning, and may even increase the risk as the individual's height is effectively increased. The interior of a vehicle offers greater protection **(C)**.
- Ceilings and overhangings do not offer safety. Large caves are suitable if we sit (better on the backpack) and stay away from the walls and the entrance (one meter from the sides of the roof and the entrance and two meters from the bottom). If the cave is the end of a crack or drain, it should be avoided.
- The walls protect if they are high (more than 15 meters) and we move 2-8 meters away from their base.
- If you are part of a group, each person must isolate himself/herself from the others and maintain a separation of 6 meters, as the bolt can jump 5 meters between objects **(C)**.
- Get away from small depressions. It is best to stand on a fine, narrow elevation, like a small loose rock on a slope.
- If you are on a platform, sit on the outer edge, preferably at 1.20 m.
- If there is a danger of falling, tie yourself as far away from your heart as possible (better by the ankle than by the armpit).
- Avoid abseiling during storms, except to escape from a more dangerous area.
- Double the attachment points on a climbing anchor.
- Metal parts do not attract lightning but are good conductors and should therefore be positioned so that they do not come into contact with the body to avoid contact burns **(C)**.
- If water activities are taking place, get out of the water and seek shelter **(C)**.
- Avoid using landline telephones during the storm.
- On a via ferrata, if there is no danger of falling it is better not to secure the ropes. If fastening is necessary, it is best to lengthen the self belay device so that the line loops and touches the ground.
- Some guides cover the holes in their helmets with adhesive tape to provide a smoother surface for the lightning bolt to slide if they are hit, but there is no evidence of the usefulness of this practice.
- Avoid draughts: close the doors and windows of cars and shelters, and stay away from chimneys.
- Wait until 30 minutes have elapsed since the last lightning strike before restarting the activity, in order to minimise the risk of

being hit by lightning from the tail end of the storm **(C)**.

In short, it is necessary to avoid conductive materials (metal, water), high structures (mountains, isolated trees), open fields and air currents (closing the windows and doors of shelters or cars, and moving away from chimneys).

A person injured by lightning, if not killed immediately and apart from superficial or deep burns, may suffer asphyxiation or syncope. In the most benign cases there will only be localised pain.

Treatment[149, 150 151]

Prehospital emergency treatment of the injured person is: cardiopulmonary resuscitation when necessary; cervical control if trauma is suspected; perfusion of saline solution to facilitate the removal of myoglobin and other byproducts of tissue damage; and treatment of burns with a localised cold, sterile dressing, as well as sedation and analgesia to relieve pain.

In the case of lightning victims, reverse triage is used, with those with no signs of life being treated first **(C)**.

Cardiac lesions

Lightning victims have no residual electrical charge, so immediate resuscitative manoeuvres are considered safe **(B)**.

Patients at high risk (suspected direct impact, loss of consciousness, neurological focus, chest pain, dyspnoea, major trauma, head and leg burns, or burns affecting more than 10% of body surface area, pregnant women) once evacuated should be studied with ECG and echocardiography **(C)**. Elevation of troponins is of no clinical usefulness as it is not correlated with anatomical lesions or prognosis **(C)**. Patients who have had a direct impact or have abnormal findings on the ECG or echocardiogram should be monitored for 24 hours **(C)**. Given the possibility of late or recurrent heart damage such as pericarditis or cardiomyopathy, patients should be advised to consult their doctor if chest pain or shortness of breath occurs.

Neurological lesions

Possible neurological lesions **(C)** should be ruled out: if the patient experienced loss of consciousness or abnormal neurological examination, a cranial CT scan **(C)** should be performed.

Keunoparalysis usually resolves spontaneously within hours. Ruling out possible spinal injury is advised as is hospital observation, as underlying serious trauma may be indicated **(C)**.

Cutaneous lesions

The appearance of transient fern-shaped lesions, called Lichtenberg figures, is pathognomonic of lightning strikes. It appears in less than 1 hour and resolves in less than 24 hours. It does not require treatment but its presence requires ruling out other lesions **(C)**.

Treat burns conventionally. Burns to the head correlate with a 3-fold increase in mortality.

Ocular lesions

An ophthalmologic evaluation is recommended **(C)**.

Auditory lesions

Tympanic rupture should be ruled out **(C)**.

Neurocognitive lesions

Psychiatric evaluation is recommended **(C)**.

Pregnancies

Foetal monitoring is required, pregnancies of less than 20 weeks are not considered viable **(C)**.

FOG

Apart from the risk of getting lost, fog can cause dizziness and imbalance when you lose your landmarks. If you are skiing, it is recommended to move slowly, looking at the tracks or skis of the skier in front of you, or at rocks, bushes or any other reference point. If GPS is not available, the best way to find your way is with a map, compass and altimeter. In case of disorientation, it is best to descend to the bottom of the valley and continue downstream until you reach a village.

Figure 9.3. Fog.

WIND

Some people are especially vulnerable to weather changes. Traditionally the wind has been linked to mental illness, Hippocrates said that the southern wind "hindered hearing and sight, carried the head and left the body languid and lazy.

Medical biometeorology is the discipline that studies the physiological and pathological processes related to meteorology. The meteorological variables most frequently associated with the aggravation of mental illness are the displacement of large masses of air and especially variations in the polarity of the ionic charge of the atmosphere.

Air ions are molecules of oxygen or water with a positive or negative electrical charge that reach a region 24 or 48 hours before the arrival of a weather front. The influence of air ions on health and performance is controversial.

The atmosphere generally has 5 positive ions for every 4 negative ions. Ion balance may be important for people's physical and mental well-being and its imbalance may cause problems in meteo-sensitive people.

Negative ions have an atmospheric concentration of 2000-4000/cm^3, are largely made up of oxygen and can have a beneficial and invigorating effect. Positive ions, made up in part of CO_2, can have a depressant and apathetic effect, which can already be apparent at concentrations of 1,000 to 2,000 positive ions/cm^3. Positive ions can decrease the capillary resistance of cell membranes by altering their permeability and can act on body water, producing variations in its physical properties and in the distribution of suspended colloids. All of this can alter the dynamics of the flow of organic fluids and produce changes in their physical properties, altering blood pressure, cardiac performance, the ability of cells to absorb water, electrical conduction between tissues and nerve stimulation.

Some authors postulate that the positive ions moving in front of dry and warm winds (mistral, foehn, etc.) enter the body through the lungs and produce an irritation syndrome, due to excess serotonin, that directly affects the pituitary and its secretion of ACTH and prolactin hormones. This may cause discomfort in sensitive individuals (fatigue, depression, irritability, migraine, asthma, oedema, palpitations and hyperactivity of the digestive tract). Other authors also attribute the calming capacity of waterfalls to the ability of water to spread negative ions through the air. In general, at sea level, the positive electrical charge predominates and in the high mountains, the negative one.

Other authors introduce the concept of the "meteoropathic front" to refer to a meteorological situation characterised by the triad

Figure 9.4. Wind.

of intense wind, environmental dryness and increased positive ionisation. This situation is associated with an increase in metabolism, abdominal meteorism, joint pain, dyspnoea, anxiety, depression, asthma, migraine, visceral spasms and allergic reactions.

A well studied phenomenon is the Foehn effect that appears when a mass of humid and cold air collides with a mountain range. When this mass falls down the leeward slopes, it becomes a mass of dry, compressed air, producing large evaporation and dissipating the clouds. The warm, dry wind drops to the bottom of the valleys, causing a sudden rise in temperature. This dry, hot wind increases the release of serotonin by 1,000% as well as increasing the production of histamine and adrenaline.

The area subjected to the Foehn effect is characterised by the existence of electromagnetic discharges with a frequency range between 1 and 100 KHz and a duration of 1/1,000 sec (called "sferics"), as well as an abundance of positive ions (4,000 cu/cm^3), while ozone is almost absent. These sferics are associated with depressive and anxiety disorders, as well as migraine, and increased aggressiveness with increased suicide and crime rates. The courts of antiquity admitted the existence of the south "Hamsa" wind as mitigating circumstances in aggressions. Currently in Switzerland, the Foehn effect is considered a mitigating circumstance in the case of committing certain offences.

In 1977, Canadian scientist F. Soyka observed that brief exposure to the positive ions of the wind at first produced euphoria and hyperactivity but, within hours, it caused insomnia, physical and mental fatigue, depression, headache, and an aggressive behavior.[152] Dr. F. Sulman remarked that the increase in positive ions caused by the dry, warm wind affects everyone, but that only a quarter of the population is particularly sensitive to its effects, affecting the nervous, hormonal and respiratory systems in particular.[153] He described three individual responses to positive ionisation:

- Fatigue due to catecholamine deficiency is associated with apathy, depression, confusion, lack of concentration, hypotension and hypoglycaemia.
- Irritation from serotonin release is associated with migraine, insomnia and irritability.
- A combination of the two is associated with hyperthyroidism.

The difficulty in clarifying the controversy is due to the fact that the concentration of ions in the air must reach a certain threshold before altering internal homeostasis and hormonal axes. This threshold is unknown and may be different for each person and depends on the interaction of all the factors that make up good health (sleep, nutrition, etc.).

10 ALTITUDE

CONDITIONS RELATED TO ALTITUDE

The air we breathe contains 21% oxygen. This proportion does not vary with altitude, but the air pressure gradually decreases causing the oxygen pressure in the lungs to decrease. For this reason, it becomes increasingly difficult to get oxygen into the blood and tissues.

Hypoxia is the result of the decrease in the partial oxygen pressure of in the inhaled air. At high altitudes the supply of oxygen to the tissues hardly exceeds the level necessary to maintain basal metabolism, and at the top of Everest man is at the limit of survival. The body must work harder to get oxygen, which is why breathing and heart rate become faster.

In a second phase, if the altitude is considerable and the permanence is longer than a week, the number of red blood cells increases to facilitate the capture, transport and transfer of oxygen to the tissues in spite of hypoxaemia.

Hypoxia also causes chemical changes in body fluids and increases urine output. Failure to increase urine output may indicate dehydration or poor acclimatisation, which is the process by which the body accommodates itself to the decrease in oxygen availability that exists at high altitude.

This situation involves some ordinary changes that can be expected:

- Tachypnea.
- Fast breathing during exercise.
- Increased urination.
- Periodic nocturnal breathing.
- Rapid breathing followed by brief breathing stops that can last up to 10-15 seconds.
- Frequent waking up during the night.
- Strange dreams.

Table 10.1. Blood oxygen pressure at different altitudes

Altitude (meters)	Oxygen blood pressure (mmHg)
0	94
1,500	75-81
2,286	69-74
4,600	48-53
5,500	40
6,100	37-45
7,620	32-29
8,848	26-33

Mountain sickness occurs when the body does not tolerate hypoxia at high altitudes. Although not a serious problem in the mountains around us, it can occur at moderate altitudes.

Mild forms can occur in 10-25% of climbers who climb and stay for a few hours at more than 2,500 m and in 30% of those who are at 3,000 m.[154, 155] From 4,500 m onwards it can affect 50-85% of climbers, causing more serious problems, and from 6,000 m onwards mortality is high, although fatal cases below 3,000 m have already been reported. Cases between 2,000 and 2,500 m have only rarely been reported. A recent study has reported

3 out of 4 climbers at 4,600 m as suffering from subclinical forms of altitude pulmonary oedema. The prevalence of cerebral oedema is 0.5-1% in people who stay for 2 days at altitudes between 4,000-5,000 m.

Poor adaptation to altitude can lead to a number of conditions, of which mountain sickness is the most common, and can lead to more serious conditions such as pulmonary oedema and cerebral oedema, which can cause death.

DIAGNOSIS[156]

When in doubt as to whether or not a condition is due to altitude, it should be considered to be caused by altitude until proven otherwise.

Mountain sickness

The mountain sickness usually appears between 6 and 10 hours of reaching high altitude, although in some cases it has already appeared after 1 hour and in others after 96 hours. It is more common in people who habitually reside at less than 900 m altitude, in people under 46 years of age, in people with a history of migraine, and in obese people. Women are less susceptible to pulmonary oedema, but have mountain sickness as often as men. Physical preparation does not protect against mountain sickness. Other risk factors are poor acclimatisation (less than 5 days above 3,000 m in the previous 2 months) and rapid ascent (more than 625 m per day above 2,000 m).

Figure 10.1. Mountaineering.

It usually improves spontaneously after 5-7 days at altitude, but sometimes evolves into severe forms such as cerebral and/or pulmonary oedema.

The diagnosis of mountain sickness is suspected if you have a headache associated with one of the following symptoms:

- Fatigue and weakness disproportionate to the intensity of physical exercise.
- Vertigo.
- Gastrointestinal symptoms (loss of appetite, nausea, or vomiting).
- Insomnia.

The headache is usually severe, throbbing, occurs at night, and does not improve with regular doses of acetaminophen (500 mg every 6-8 hours) or ibuprofen (400-600 mg every 6-8 hours).

The following may also appear:

- A persistent cough, choking at medium effort and lung rales.
- Irritability.
- Alteration of the gait.
- Decreased amount of urine.

The ascent should not be continued with symptoms of mountain sickness, as it may worsen and lead to death from cerebral oedema.

Lung oedema

Pulmonary oedema appears during the first week at high altitude and its diagnosis requires at least two symptoms and two signs from the following list:

Table 10.2. Lake Louise Scoring System (LLSS) for diagnosis of acute mountain sickness

Symptomatology	Score		
Headache	Absent Slight Moderate Severe		0 1 2 3
Gastrointestinal symptoms	Good appetite Poor appetite or nausea Moderate nausea or vomiting Severe nausea or vomiting		0 1 2 3
Fatigue and/or weakness	Absence of fatigue Mild fatigue or weakness Moderate fatigue or weakness Severe or disabling fatigue or weakness		0 1 2 3
Dizziness or light-headedness	Absent Mild dizziness Moderate vertigo Severe vertigo		0 1 2 3
According to the score obtained	Mild Acute Mountain Sickness	Moderate Acute Mountain Sickness	Severe Acute Mountain Sickness
	1-3	4-6	>6

Table 10.3. Symptoms and signs of pulmonary oedema

Symptoms	Signs
Weakness, fatigue, decreased physical fitness. Cough. Rest breathlessness. Thoracic congestion or oppression.	Rales or wheezing, in at least one lung. Cyanosis. Tachycardia. Tachypnea. Low-grade fever Pinkish sputum

Not to be confused with coughing from high altitude exposure.

It can develop into cerebral oedema and cause death within a few hours.

Cerebral oedema

Cerebral oedema is characterised by:

- Mental state and/or gait disorders in people with or without symptoms of mountain sickness. They look as if they were drunk, unable to walk in a straight line with one foot in front of the other. Feverishness.

It can evolve into coma and death in a few hours.

Other pathologies related to altitude

- Retinopathy: usually asymptomatic and resolves spontaneously in one or two weeks. Good hydration is recommended to reduce the blood concentration, and to descend if visual disturbances appear.
- Peripheral oedema of the hands/face: it can be treated with diuretics if there is no concomitant mountain sickness.
- Venous stasis and thrombotic complications: due to a combination of dehydration, excess of red blood cells, tight clothing and cold. Stay active, well hydrated and descend if necessary.
- Immunosuppression with increased susceptibility to bacterial infections.
- Pharyngitis and bronchitis: coughing from exposure to high altitudes is not accompanied by fever, choking at rest or bluish

skin and pulmonary auscultation shows no rales or wheezing noises. It can be partly prevented by wearing face masks and a good hydration. It is symptomatically treated with 30 mg codeine every 4-6 hours.

- Keratitis from ultraviolet rays.

Prevention[156-161]

The time needed to adapt to heights is variable. Respiratory and biochemical changes may occur in 6-8 days, but the increase in red blood cells requires 6 weeks to reach a maximum of 90%. Typically, an adaptation of 80% is achieved after 10 days and of 95% after 6 weeks.

Risk of mountain sickness

Table 10.4. Risk of mountain sickness (the start of the ascent is assumed at an altitude <1,200 m)

Low	• Individuals with no previous history of mountain sickness ascending to an altitude of 2,800 m or less • Individuals who spend 2 days in ascending to 2,500-3,000 m increasing the overnight stay <500 m/day. • Individuals who ascend at a speed of more than 500 m/day (overnight stay) above 2,500 m and are partially acclimatised (exposure to altitude <3,000 m in the previous weeks).
Moderate	• Individuals with a previous history of mountain sickness ascending to 2,500-2,800 m in 1 day • Individuals with no previous history of mountain sickness who ascend to altitudes above 2,800 m in 1 day • Individuals who ascend at a speed of more than 500 m/day (overnight stay) above 3,000 m.
High	• Individuals with a previous history of mountain sickness who ascend to altitudes above 2,800 m in 1 day • Individuals with a history of pulmonary or high altitude cerebral oedema • Individuals who ascend to more than 3,500 m in 1 day • Individuals who ascend at a speed of more than 500 m/day (overnight stay) above 3,500 m. • Very fast ascents (e.g. Mt. Kilimanjaro).

Preventive measures

Acclimatisation before the ascent: staying for one week at altitudes between 2,000 - 3,000 m more than 8 hours a day before the ascent to 4,300 m reduces the incidence of mountain sickness by 50%. It can be combined with intermittent hypoxia training programmes at simulated altitudes of 4,000-5,500 m (12-15 sessions of 60-90 minutes).

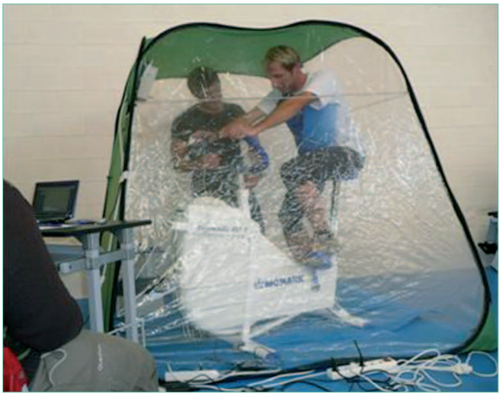


Figure 10.2. Hypoxia altitude simulation test.

- Gradual ascent: despite the current trend towards rapid ascents, with safety achieved by being less exposed to the risks of the mountain, the risk of mountain sickness is lower with the following rate of ascent: spend at least two nights at 2,500-3,000 m From 2,500 m onwards, do not exceed 600 m altitude difference every night, even if higher altitudes are reached during the day. Every 1,000 m of slope, spend a second night at the same altitude as the night before. Above 3,000 m, do not make intense efforts; climb slowly, do not exceed 300-500 m of incline daily and rest 1 day for every 2-4 days of ascent. At altitudes above 5,000 m, a 200 m ascent per day in people with moderate mountain sickness has precipitated a cerebral oedema **(B)**. The altitude at which you stay overnight is more important than the altitude you reach during the day.

- An ascent with symptoms of mountain sickness should not be initiated. If symptoms of bad acclimatisation appear, you should stop ascending.
- The best prevention of brain swelling is to lose altitude when symptoms of mountain sickness appear.
- Keep good hydration and a varied diet with a high percentage of carbohydrates. Dehydration is the leading cause of headache at altitude. If, after drinking a litre of water and taking a pain relief tablet, the headache subsides completely and there are no other symptoms of mountain sickness, it can be attributed to dehydration.
- The risk of headache is reduced with the administration of 3 x 320 mg doses of acetylsalicylic acid taken at 4-hour intervals, starting 1 hour before ascent; or ibuprofen 600 mg every 8 hours starting a few hours before ascending to altitudes between 3,480-4,920 m.
- Acetazolamide at a dose of 125 mg every 12 hours, starting the day before the ascent and continuing until 2-3 days after reaching the expected altitude, may be useful in cases of moderate or high risk, but is not generally recommended because of the dehydration that may occur with increased diuresis. It may be useful for improving periodic night-time breathing causing disturbances (125 mg one hour before bedtime). It is recommended when there is a previous history of mountain sickness, or when a quick ascent is inevitable (rescue group, flight to a city at high altitude: Lhasa, etc.). Its effect begins after 24-48 hours. It cannot be given if there is an allergy to sulphonamides. The most common side effects are tingling and taste disturbances that occur when the medication is withdrawn **(A)**.[162]
- Dexamethasone at a dose of 2 mg every 6 hours or 4 mg every 12 hours for a maximum period of 10 days may be helpful if acetazolamide **(A)** cannot be used.
- Only in situations of extreme urgency (rescue group) can the combination of acetazolamide with dexamethasone or high doses of dexamethasone (4 mg every 6 hours) be evaluated.
- Nifedipine at a dose of 20 mg every 8 hours may be helpful in climbers with a previous history of pulmonary oedema. It should be administered under medical supervision, as it may cause hypotension and tachycardia (A). Other drugs that may be useful in the prevention of pulmonary oedema include 5-phosphodiesterase inhibitors (e.g. tadalafil 10 mg /12 h) or dexamethasone 8 mg /12 h **(C)**.

TREATMENT (C)[156, 159-161]

Mountain sickness

Table 55. Treatment of mountain sickness according to severity

Mild mountain sickness (1-3 points)	• Rest, hydration. • Ibuprofen (400-600 mg every 6-8 hours) or paracetamol (1 g every 6 hours).[163]
Moderate mountain sickness (4-6 points)	• Stop the ascent until a complete improvement occurs, if it does not improve within 24 hours, descend 300-1,000 m **(A)**. • Ibuprofen (400-600 mg every 6-8 hours) or paracetamol (1 g every 6 hours).[163] • Acetazolamide 250 mg every 12 hours **(B)**. • Antiemetics.
Severe mountain sickness (more than 6 points)	• Descend to the level where there were no symptoms **(A)**. • Oxygen to maintain oxygen saturation above 90% (2-4 L/min) **(C)** or use a hyperbaric chamber until lowering or evacuation is possible. Hyperbaric chamber if possible **(B)**. • Dexamethasone 8 mg followed by 4 mg/6 h.

The descent to the altitude where there were no symptoms should not be delayed until the next morning. Particularly those with pulmonary oedema can quickly develop cerebral oedema and die. Do not leave a climber alone with symptoms of mountain sickness.

Do not restart the ascent until there is a full recovery without drugs; consider the preventive administration of acetazolamide 250 mg/12 h.

Pulmonary oedema

- Descend at least 1,000 m and continue the descent until the symptoms resolve **(A)**.
- Oxygen to maintain oxygen saturation above 90% (2-4 L/min) **(B)** or use a hyperbaric chamber until lowering or evacuation is possible. Hyperbaric chamber if possible **(B).**
- Nifedipine 20 mg every 8 hours as adjuvant therapy if no oxygen or hyperbaric chamber **(C)** is available.
- Warmth and rest.

Pulmonary oedema can evolve into cerebral oedema and cause death within a few hours if altitude is not quickly lost to the level where there were no symptoms. If in doubt, descend 1,000 m or to the level where you have slept the previous two nights. A delay can be fatal, so it should not be postponed until the next morning. There is insufficient evidence as to the benefit of acetazolamide, dexamethasone, sildenafil and tadalafil.

Do not restart the ascent until a full recovery has occurred without medication, and consider the preventive administration of dexamethasone 20 mg/8 h.

Cerebral oedema

- Descend at least 1,000 m and continue the descent until the symptoms resolve **(A)**.
- Oxygen to maintain oxygen saturation above 90% (2-4 L/min) **(C)** or use a hyperbaric chamber until descending or evacuating is possible. Hyperbaric chamber if possible **(B)**.
- Dexamethasone: 8 mg of intake followed by 4 mg every 6 hours **(B)**.
- Warmth and rest.

You can die within a few hours if you don't lose altitude quickly to the level where there were no symptoms. If in doubt, descend 1,000 m or to the level where you have slept the previous two nights. A delay can be fatal, so it should not be put off until the next morning.

Do not restart the ascent until there is a full recovery without medication; consider preventive administration of acetazolamide 250 mg/12 h.

11

ANIMAL BITES AND STINGS

MAMMAL BITES[164]

Animal bites in the mountains are rare. If they do occur, they should be treated as a wound contaminated by oral bacteria.

Treatment (A)

- Wound inspection.
- Clean with plenty of water, soap and povidone iodine.
- Keep the limb elevated and immobilised.
- Assess debridement and removal of devitalised tissue.
- Suture assessment, prophylactic antibiotic treatment and tetanus vaccination.

When to stitch?

They can be sutured if they meet the following three criteria **(B):**

- There is no clinical infection.
- The wound does not affect the hands or feet.
- Less than 12 hours have passed since the bite (24 hours on the face). Infections of the face have a low risk of infection (0.4%), possibly due to good irrigation of the face and scalp.

Use subcutaneous sutures with caution, as a foreign body (thread) in a contaminated wound increases the risk of infection. Avoid suturing with cyanoacrylate (glue).

Do not suture wounds with a high risk of infection **(C):**[165]

- Crush injuries
- Puncture wounds
- Bites that affect the hands or feet
- Injuries more than 12 hours old (24 hours on the face)
- Injuries from cat or human bites, except on the face.
- Wounds in immunosuppressed people (for example splenectomised, diabetics, etc.).

When to administer prophylactic antibiotic treatment?

Its routine use is not recommended. Justified for high-risk wounds (e.g. amoxicillin with clavulanic acid 500/125 mg every 8 hours or, in case of allergy, ciprofloxacin 750 mg every 12 hours for 10-14 days).[166] Fluoroquinolones should be reserved to be used in patients with no alternative treatment options:

- Deep puncture wounds, especially from cat bite.
- Severe or moderate injuries with associated bruising.
- Wounds in areas with underlying venous or lymphatic involvement.
- Injuries to the hands or near a bone or joint
- Wounds that require stitches.
- Wounds in immunocompromised patients (e.g. splenectomised, diabetics, etc.).
- In dog bites, the risk of infection is reduced by 50%.[167]

When to administer booster doses of the tetanus vaccine in adults?

- Those who were correctly vaccinated in childhood and adolescence (currently 2, 4, 6 and 18 months; 4 and 14 years): single booster dose at age 65.
- Incomplete vaccinations in childhood and adolescence or primo-vaccinated in adolescence or adulthood with less than 5 doses:
  - — Complete the first vaccination with Td (tetanus, diphtheria) (0, 1 and 7 months)

Table 11.1. Anti-tetanus wound prophylaxis

Tetanus vaccine doses received	Clean wounds	Potentially tetanigenic wounds
<3 doses	Begin or complete vaccination	Initiate or complete vaccination plus anti-tetanus gamma globulin
3 or 4 doses	One dose of vaccine if more than 10 years after the last dose	One dose of vaccine if more than 5 years have passed since the last dose
5 or more doses	Nothing	One dose of vaccine if more than 10 years have passed since the last dose

  - Complete vaccination with two booster doses every 10 years. After completion of adult vaccination with 5 doses, no further booster doses are necessary until the age of 65 if more than 10 years have elapsed since the 5th dose was administered.

Bats

Since 1987, there have been six cases of rabies in Spain, all transmitted by bat bites.

Prevention

Avoid picking up or touching bats.

Treatment

- Cleaning the wound with soap and water. Disinfection with povidone-iodine.
- Administer rabies immunoglobulin at a dose of 20 IU per kg body weight intramuscularly, delivering at least 50% near the wound **(A)**.
- Intramuscular rabies vaccine in the deltoid region (not in the buttocks) **(A)**.[168]
  - Abbreviated pattern:
    - Day 0: 1 dose in the right arm and another one in the left arm.
    - Day 7: 1 dose.
    - Day 21: 1 dose.

ARTHROPOD BITES[169-171]

Arthropods are invertebrate animals with articulated legs. Some produce substances that are harmful to the human species.

Table 11.2. Most representative arthropods in our environment

Insects	Hymenoptera: ants, bees, wasps and bumblebees. Diptera: mosquitoes and horseflies. Lepidoptera: pine processionary. Hemiptera: Bedbugs
Arachnids	Ticks, spiders and scorpions
Chilopoda	Scolopendras

Insects

Hymenoptera

Ants

Being less mobile and unless their habitat is disturbed, they are less aggressive than other hymenoptera. In the Iberian Peninsula there is a poisonous ant, the small red ant (*Myrmica rubra laevinoides*), which has an abdominal stinger, however its stings are not severe.

Honeybees, bumblebees and wasps

Bumblebees (*Bombus, Megabombus* and *Pyrobombus*) are less aggressive than honey bees and only sting if they are disturbed, producing symptoms similar to other bee stings. Only worker bees have a stinger, which is nonexistent in males or drones. Consisting of a stylet and two lancets, the stylet partially sheaths the lancets and encloses the venom channel between the three. When it stings, the stinger is inserted perpendicularly, and the lancets move forward, alternately, enlarging the wound by puncturing the stylet and pumping the venom into the wound. Unlike wasps and ants, the bee sting is harpooned and is fixed to the skin after the sting. The bee cannot remove it without tearing part of its distal intestine, causing its death. On the other hand, the wasp sting is smooth, being able to produce several successive stings without it becoming harpooned and fixed to the skin.

Hymenoptera venom is composed of proteins, polypeptides and aliphatic constituents. Among them, phospholipase A_2, hyaluronidase and acid phosphatase have a high antigenic and sensitising capacity.

Apamine is neurotoxic and melittin has a high affinity for cell membranes, altering phospholipids and producing cell lysis. The MCD or PDM peptide promotes mast cell degranulation and may produce local inflammatory reactions of non-immunological origin. The difference in composition between the different venoms (wasp antigen-5) is responsible for the differences in local reactions and degrees of sensitisation of each species.

In Europe and the USA, death by hymenoptera stings is more frequent than by snake bites, but it should be noted that the frequency of stings is higher. Studies show that 56.6% of the population in Italy or 61% in Turkey have been stung at least once in their lifetime by hymenoptera. In the United States, 30 to 120 people die each year from wasp and bee stings. In some cases, such as the honey bee (*Apis mellifera*), they live in large colonies and hundreds of thousands of bees may sting, because if they feel threatened they release odoriferous alarm substances that attract their closest companions. These massive amounts of stings (20 or 30) can be fatal. More than 100 stings in children and 200-500 in adults are usually fatal.

Signs and symptoms

Local reactions

Are the most frequent and are produced by the proteins and amines in the poison; the most important is the action of histamine, which produces vasodilatation and oedema. A very painful macule-papule appears, about 2 cm long, which usually subsides in a few hours. Sometimes, the macule-papule is larger than 10 cm, can affect the entire limb and persists for more than 24 hours. Such reactions do not presuppose an increased risk of systemic reactions to further stings. Localised stings in the neck or pharynx area can cause airway obstruction by local oedema, even without an anaphylactic reaction.

Systemic reactions (10% of cases)

a) Multi-bite toxicity: these are widespread reactions that do not require prior sensitisation (non-immunological), originating from the inoculation of a large amount of venom when suffering multiple stings.

Symptoms depend on the release of biogenic amines (adrenaline, noradrenaline, serotonin, acetylcholine) into the bloodstream and mainly on the inoculation of large quantities of histamine.

They resemble anaphylactic reactions, but usually have some characteristic symptoms and a greater prevalence of gastrointestinal symptoms:

- Headache, fever, muscle spasms and convulsions.
- Vomiting and diarrhoea.
- Generalised oedema and hives.
- If the reaction is severe: cardiac depression, arrhythmias, hypotension, renal failure, shock and death.

The severity depends on the total number of stings (very dangerous if more than 20-30) and the previous condition of the patient (age, previous heart disease, etc.).

b) Immunological: Most fatal cases are due to allergic hypersensitivity after a first sensitising sting. The reactions can be grouped into three groups:

b.1. Immediate anaphylactic reactions (type I hypersensitivity): In previously sensitised individuals, re-sensitivity of a Hymenoptera will result in antigen recognition by B lymphocytes with specific Ig E production and degranulation of mast cells and basophils. This degranulation produces the release of histamine, SRS-A (slow-reacting anaphylaxis substance), ECF-A (eosinophilic chemotactic activity factor) and other inflammatory mediators, with a subsequent hypersensitivity reaction to a greater or lesser degree.

The reaction begins a few minutes after the sting with generalised itching, hives, rhinorrhoea, tearing, nausea and vomiting, coughing, the sensation of a foreign body in the pharynx, bronchospasm, laryngeal stridor due to oedema, angioedema or anaphylactic shock. Death occurs from airway obstruction or shock, usually within the first 30 minutes to 4 hours. In Spain, a mortality rate of 0.08 deaths per million inhabitants per year has been published. In France and Switzerland it is estimated at 0.45 cases per million inhabitants per year. There is no correlation between the number of bites and the magnitude of the reaction, as it depends on the degree of prior sensitisation, so a single sting can be fatal.

b.2. Large local reactions (type IV hypersensitivity): these are rare, are mediated by T cells and are characterised by the late onset of a large local inflammatory reaction at the site of the bite, which persists for more than one day.

b.3. Late reactions (hypersensitivity type III): these are mediated by the formation of immunocomplexes between components of the venom and immunoglobulins which, when deposited in the different tissues, can cause lesions in different organs, with the appearance of urticaria, arthralgia, fever, angioedema, proteinuria, vasculitis and nephrotic syndrome.

Prevention

People who are sensitive to stings should follow preventive measures such as not picking flowers, avoiding walking barefoot on the lawn, avoiding gardening, not using perfumes or bright colours, and wearing long-sleeved clothing when going outdoors; do not eat sweets or drink sugary beverages in the open air, eliminate hives near inhabited areas (which should be removed by other people), not to get agitated or nervous when seeing bees or wasps, as this seems to excite and attract them; assess whether to carry a pre-filled syringe with adrenaline, etc.

Repellents can be applied, the most effective ones contain DEET (N, N-Diethyl-m-Toluamide); the DEET content does not mean better protection, but longer-lasting protection. The duration of protection does not increase with a concentration of DEET greater than 50 %; Picaridin may also be used.[172]

Table 11.3. Duration of protection according to the DEET concentration

DEET concentration	Duration of protection
23.8 %	5 horas
20 %	4 horas
6.65 %	2 horas
4.75 %	1.5 horas

A soy oil-based repellent provides protection similar to a repellent with 4.75% DEET

Do not spray directly on the face, hands should be sprayed and then rubbed on the face avoiding the eye and mouth area. Do not apply on wounds or irritated skin. After use, the skin should be washed with soap and water.

60% of patients who have had severe reactions develop anaphylaxis in response to further stings, so an allergist should assess whether desensitisation with hymenopteran venom is indicated. This can lead to desensitisation to 98%, after three years of treatment, with a maintenance dose of 100 mcg, every four or six weeks.[173, 174]

Treatment (C)[173]

Local reaction

- Remove the stinger without pressing to avoid emptying the rest of the contents of the sac or inserting it further. By dragging it out, such as with a credit card, knife, tweezers or razor; the vibration of an electric razor can increase the inoculation.
- Apply ice wrapped in a cloth locally for about 15 minutes.
- Raise the limb.
- Administer analgesics: paracetamol 500 mg every 6-8 hours if you have pain.
- In case of inflammation, 1% hydrocortisone ointment may be applied.

- Evaluate the administration of antihistamines: dexchlorpheniramine (2-6 mg every 6-12 hours), or cetirizine, loratadine or ebastine (1 tablet every 24 hours).
- If the local reaction is significant, administer corticosteroids: methylprednisolone 0.5-1 mg/kg/day for 5 days **(C)**.
- Tetanus vaccination.

Systemic reaction

- Keep the airway open by intubating or performing cricothyroidectomy if required and oxygen therapy if necessary. In case of laryngospasm: adrenaline and corticosteroids.
- Administer adrenaline SC every 10 minutes if necessary, with local massage to improve absorption, 1/1,000 0.3-0.5 mL in adults and 0.001 mg/kg by weight up to a maximum of 0.3 mg in children. The doses can be repeated after 10 or 15 minutes depending on progress. In severe cases, an vial of adrenaline may be used, (1 mg) IV diluted in 9 cm^3 of physiological saline solution administered in 2-3 mL repeated boluses, equivalent to 0.2-0.3 mg.
- If hypotension is present, administer physiological saline solution (20 mL/kg bolus which can be repeated if necessary). Acute tubular necrosis can be prevented with a good diuresis. Administration of antihistamines by intravenous route: dexchlorpheniramine 5 to 10 mg IV.
- Intravenous administration of corticosteroids: hydrocortisone 10 mg/kg, 6 methylprednisolone 1-2 mg/kg.
- In case of severe bronchospasm, administer adrenaline 0.3-0.5 mg SC.
- ß2 aerosols: salbutamol 2 mL of spray solution for three minutes or terbutaline. In severe cases, salbutamol IV may be used.
- If the response is low, intravenous aminophylline 5.4 mg/kg diluted in 100 cm3 of physiological serum may be added to be passed in 15 to 20 minutes and then infused at a dose of 0.4 mg/kg/hour.
- Patients with a history of insect sting anaphylaxis are advised to carry a pre-filled adrenaline syringe and be instructed in its use.

Dipterans: mosquitoes and horseflies

Their bites produce a very itchy papule preceded by redness and swelling, and in the case of the horsefly, a deeper subcutaneous induration with extravasation of a small amount of blood. These injuries can persist for hours to days. Blisters, hives, fever, and general malaise may occur in sensitive individuals.

Treatment is symptomatic and pain relievers such as paracetamol, topical ammonia for pain relief, or a 1% hydrocortisone ointment may be applied.

*Lepidoptera: pine processionary (*Thaumetopoea pinivora*)*

Some lepidopteran caterpillars produce hives because they are covered with a multitude of hairs with glands that release urticating substances. In Europe, hives caused by the pine processionary are frequent in children who, attracted by the rows of caterpillars, play with them. Placing surgical or adhesive tape on the irritated skin and then pulling it off will remove any attached hairs. It can be applied with 1% hydrocortisone ointment and, if the itching is intense, an oral antihistamine.

*Hemiptera: bed bugs (*Cimex lecturalius*)*

Bedbugs are mainly nocturnal parasites, which is why they are often found in bedrooms. They resist adverse temperatures, so they can also be found in unheated bedrooms.

They do not live on humans, unlike lice, but bite to feed on blood and then leave the skin and lodge in some crevice in the bedroom. The presence of droppings, similar in appearance to black fountain pen ink splashes, can be detected in mattresses, crevices, etc.

They bite exposed skin areas not covered by pyjamas. It may take up to 10 days after the bite for the lesions to appear. These are skin lesions with swelling, redness and itchy irritation that usually resolve within a week. Scratch infections may also occur. They do not transmit hepatitis C or AIDS although cases of hepatitis B transmission have been reported.

Insect repellents are not very effective for bed bugs and they often develop resistance, so hygiene is key to prevention.

Treatment is based on the administration of antihistamines to relieve itching.

A 90-minute exposure of the bug to 48-50 °C destroys it at any stage.

Arachnids

Ticks

Ticks are arachnids that parasitise mammals, birds, reptiles and amphibians. Only mosquitoes transmit diseases to humans more frequently than ticks. There are 800 known species and they are classified into two families: hard ticks or *Ioxididae*, and soft ticks or *Argasidae*.

The juvenile forms live in the grass until they adhere firmly to the skin of some animal, developing a distended abdomen over successive days. Almost any species of tick can parasitise the human species, usually sticking to the scalp, behind the ears and in skin folds.

More than because of their attachment to the skin, ticks are frightening because approximately 20% are parasitized by rickettsias that can transmit diseases, among which the most important is Mediterranean spotted fever, also known as Boutonneuse fever.

Signs and symptoms

Mediterranean spotted fever is the most common rickettsiosis exanthematica in the countries of the Mediterranean basin, where it is endemic. It is caused by rickettsia conorii and is transmitted by the most common dog tick. It appears mainly in the summer, with a maximum incidence in August, coinciding with the life cycle of the tick, which infests dogs from the beginning of summer.

Clinically it manifests itself as an acute febrile illness, causing headache, muscle and joint pain, a rash with raised spots on the skin and, in 75% of patients, an inoculation lesion in the form of a black spot.

The incubation period ranges from 4 to 20 days. Often, the bite goes unnoticed. The inoculation lesion is painless, is found in 75% of cases and can be multiple; it is usually located in covered and flexion areas (armpit, groin, interdigital area, pubic area, behind the ear, scalp, sub mammary area, hollow behind the knee), which makes it difficult to detect. In children, it predominates in the head, and in the extremities in adults. Initially, it is a small pustule that a few days later becomes the characteristic black spot of the disease, consisting of an ulcerative lesion covered by a black eschar surrounded by a reddish halo. This black spot persists throughout the feverish period and may be accompanied by regional ganglia.

The clinical manifestations are abruptly established with high fever, headache, mental torpor, photophobia, intense effect on the general state, and muscle and joint pain, especially in the lower extremities. Bilateral conjunctivitis can occur in 9% of cases. The rash appears within 3-5 days of the onset of the fever, usually affecting the palms of the hands and soles of the feet. One third of patients have vomiting, diarrhoea or abdominal pain.

Generally it is a benign disease, but 7.5% can present severe forms with serious organic involvement (renal, respiratory, neurological, cardiac or hepatic), and although it is generally not fatal, lethal cases have been reported in up to 2.5% of patients. The majority of fatal cases have occurred in the elderly, alcoholics, people with heart failure or chronic obstructive respiratory disease, and in patients in whom the introduction of treatment was delayed for more than seven days after the onset of fever, highlighting the need for early treatment without waiting to receive a serological analytical confirmation.

Prevention

- Detect the presence of ticks and know the diseases they can transmit.
- Avoid tick areas.
- Wear long trousers, long socks and long-sleeved T-shirts.
- Wear light-coloured clothing.
- Tuck the shirt inside the trousers and the trousers inside the socks or boots (including sealing them with adhesive tape).
- Walk along the trails to avoid contact with dense vegetation.

- Avoid sitting directly on the ground or on the grass, use a blanket or towel.
- Check your skin and clothing regularly if you are in areas heavily infested with ticks. At the end of the activity, check the whole body.
- Use a repellent with DEET. Repellents with permethrin can be applied lightly and in small amounts to clothing or bedding and last up to a month despite washing clothes. They should never be applied directly to the skin as they can cause neurological damage in mammals.
- Remove the tick properly.

Treatment (C)

Sometimes ticks don't bite into the skin until hours after the first contact, so they are easy to remove at first, but once they do bite into the skin, which they do completely painlessly, it is more difficult.

Technique to eliminate ticks

- It is not recommended to bring a hot match, petroleum jelly, liquid soap, petroleum, gasoline or nail polish close to the tick, as it can prolong the exposure time and the tick responds to the irritation by injecting the infectious organisms through the wound it has produced into the skin. Sometimes, the tick comes off by attaching a dog tick collar to the wound.
- Fine-tipped tweezers and gloves are used, as handling ticks without gloves may cause infection through skin cracks.
- Take the tick as close to the surface of the skin as possible and pull it up gently and firmly to remove it. The tick should be grasped perpendicular to its axis. If it is grasped along its axis it could become a kind of syringe and inject all its germs. Do not twist or shake it. By pulling slowly and firmly, it is practically impossible to rip its head off. Sometimes a small piece of skin comes off when the tick is removed, which means it was done correctly. Avoid bursting the tick so that its remains do not contaminate either the person affected or the person helping them.
- Disinfect the skin with soap and water or iodine and cover with a bandage. Disinfect the tweezers after use.
- A nodule may form at the site of the bite with very itchy blackish remains that may persist for several years.
- See your healthcare provider for follow up on the injury. Except in certain cases, there is no evidence of the usefulness of chemoprophylaxis after a tick bite.
- Treatment of Mediterranean spotted fever consists of oral doxycycline (200 mg/12 h in adults and 5 mg/kg/12 h in children for one day) or ciprofloxacin 500 mg/12 h, 4 doses. Fluoroquinolones should be reserved for patients who have no alternative treatment options.

Spiders

Spiders possess venom to paralyse insects and dissolve their tissues in order to absorb them, leaving the chitin exoskeleton empty. Of the 50,000 known species, only about a dozen are dangerous to humans, as most of the time the spider is unable to penetrate human skin when it bites.

There are three species potentially toxic to humans in the Mediterranean region: *Latrodectus* (black widow), *Lycosa fasciventris* (tarantula) and *Loxosceles rufescens* (brown or corner spider). The venom can range from mild local inflammation to skin necrosis and hemolysis. There are proteolytic (*Lycose*), proteolytic and hemolytic (*Loxosceles*) and neurotoxic (*Latrodectus*) poisons.

Another species of spider present in the Iberian Peninsula that can bite humans is the black cork oak spider (*Macrothele calpeiana*), without any serious case having been reported in our environment.

Latrodectus (black widow)

Widow spiders belong to the genus Latrodectus. Its name comes from the fact that the 13 mm female, after copulation, eats the 6 mm male. The black widow has a neurotoxin that rarely causes death. There have been no deaths from black widow bites in the USA since 1983, although one case has been reported in Greece. In the Iberian Peninsula there is the *Latrodectus tredecimguttatus,* which is found in Valencia, Andalusia and in the greenhouses of Almeria.

Signs and symptoms

Only a puncture and redness of the skin is noticed when bitten. Afterwards, a very painful erythema urticariforme (red-vine elevation of the skin) appears, with local oedema that may develop into necrotic sloughs, as well as local ganglion cysts.

In severe cases, generalised muscle spasms and contractures may occur after 15-120 minutes, especially in the lumbar and thoracoabdominal region, with bending of the limbs over the trunk and an inability to stand and walk. The face has oedema of the eyelids, blepharoconjunctivitis and pained expression. There is also burning on the soles of the feet, hyperreflexia, sweating, heavy salivation, runny nose, oliguria, agitation, bradycardia, miosis, hypertension, convulsions, nausea, vomiting and poor general condition. The evolution is favourable in 95% of cases.

Treatment (C)

- Apply cold locally for about 15 minutes with ice wrapped in cloth.
- Use benzodiazepines to treat muscle spasms.
- Hypertension is resolved with bed rest, opioid analgesics, and diazepam.
- Antilatrodectus serum may cause severe allergic reactions and is therefore reserved for significant reactions in people who are under 16 or over 60 years of age, children weighing less than 15 kg, pregnant women and cardiac patients.

Lycosa fasciventris (tarantula)

Wolf tarantulas or spiders belong to the Lycosidae family, live in dry and semi-desert areas of temperate and tropical countries, and excavate their nests in the ground or among rocks. In southern Europe we find *Lycosa radiata, Lycosa tarentulla* (*L. fasciventri*).

Tarantulas are docile spiders and their venom is rarely toxic to humans. The bite may be painful, but it is not dangerous. Clinical manifestations are similar to that of the hymenopteran bite, with mild allergic reactions predominating; no systemic reactions have been reported.

Treatment is symptomatic as in the case of Diptera.

Loxosceles rufescens (Mediterranean recluse spider)

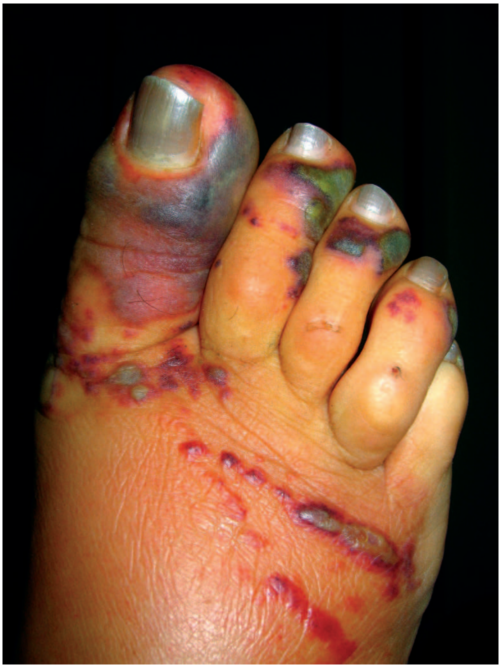


Figure 11.1. Picadura de *Loxosceles rufescens.*

Recluse or brown spiders belong to the genus Loxosceles. They are small (10-15 mm), brown in colour and with a violin-shaped pattern on the dorsal part of the cephalothorax. *Loxosceles rufescens* live in the Mediterranean area and on the Iberian Peninsula and their bites cause only local oedema with little or no necrosis.

Signs and symptoms

A very painful red papule appears for 24 hours and turns black. It may be accompanied by fever, vomiting, and muscle and joint pain. In rare cases, haemolysis may occur within 2-3 days.

Treatment (C)

- Local disinfection.
- Subcutaneous infiltration with local anaesthesia.
- Topical cure.
- Assess for antibiotics and corticosteroids.
- Observation for three days for the risk of haemolysis. Leucocytosis greater than 20,000 indicates severity.

Scorpions

Of the 1,500 existing scorpion species, only 50 are dangerous to humans. They are arachnids, with large claws or pedipalps, smaller chelicerae, four pairs of legs, a cephalothorax, an abdomen made up of seven broad anterior segments and five narrower and elongated ones that form a kind of tail, at the end of which there is the last segment called telson that contains two poisonous glands; these glands flow through two holes in the appendage of the aculeo, a sting that is curved into a nail or hook. This stinger serves to capture the insects that are its prey and as a defensive function. They are nocturnal and hide under rocks or logs during the day. They live in deserts, steppes and arid and stony places.

In the Iberian Peninsula the most common species is the European or yellow scorpion (Buthus occitanus) at about 8 cm in length. The European black scorpion also inhabits the humid and northern regions of Spain, measures about 4-5 cm and is black. Its sting produces a slight, fleeting pain. 100 cases of scorpion stings were reported in Spain between 1974 and 1978, and 976 cases were reported in France between 1973 and 1994, most stings occurring in warm weather.

Scorpion venom contains multiple basic proteins (neurotoxins) of low molecular weight, mucins, salts, inorganic compounds (oligonucleotides, amino acids), serotonin (which contributes to local pain), enzyme inhibitors, etc.

The mechanism of poisoning begins with a local action due to serotonin and continues with a neurotoxic action on the sympathetic and parasympathetic hypothalamic autonomic nerve centres. This is an autonomic effect similar to that of nicotine, which causes bradycardia and hypotension, followed by tachycardia and hypertension, adrenal medullary stimulation to produce adrenaline, hyperglycaemia, rapid breathing, hyperperistaltism and mydriasis.

Signs and symptoms

The severity of the sting depends on the species involved and the age of the victim. The mortality from stings of the most poisonous species can reach 20% in infants, 10% in children and 1% in adults.

The sting of the European scorpion is considered to be of medium danger, producing intense pain of immediate onset which, without treatment, can last up to 72 hours. There is swelling and bloody blisters at the site of the sting. Headache, vomiting, fever, dizziness and discreet choking may occur. Systemic reactions are rare and symptoms usually subside within 48 hours. They begin with restlessness, nasal itching, high blood pressure, and heavy salivation. It can only be severe in young children. Severe cases of cardiovascular failure, respiratory failure, convulsions or anaphylactic shock are exceptional, with only one case of death reported in the province of Córdoba and in unclear circumstances.

Treatment (C)

- Local disinfection.
- Subcutaneous infiltration with local anaesthesia without adrenaline.

Chilopoda

The most important is the Scolopendra, which injects a poison that produces intense pain, redness of the skin and local oedema that resolves in 48 hours. Treatment is symptomatic, as is the case with Diptera.

SNAKE BITES

Overview

Two kinds of poisonous snakes are found in the Pyrenees:

***Viper* (*Vipera aspis*, *Vipera latastei* and *Vipera seoanei*):** With a length of 60-90 cm, it is active in both the day and at night, it does not attack without being stepped on and rarely causes fatal accidents due to its small size and the small amount of poison injected. Despite avoiding extreme heat and cold temperatures and high altitudes, the *Vipera aspis* can be found up to 2,900 m, the *Vipera latastei* up to 2,000 m, and the *Vipera seoanei* up to 1500 m.

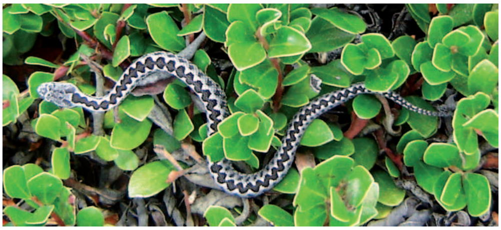


Figure 11.2. *Vipera aspis.*

***Malpolon monspessulanus**,* commonly known as the **Montpellier snake:** 2-2.5 m long, it lives in bushes, trees and areas of crops, is found at altitudes up to 1,500 m and is active in the daytime. It climbs and even swims, is aggressive, emits a whistle, puffs up its neck and can rear up. It is the largest snake and causes only minor accidents, never fatal.

Snake bites are most common in the spring and autumn and mainly affect the arms. It is not a rare pathology (2,000 bites per year in France with 23 deaths between 1958 and 1965). In Spain, according to data from the Carlos III Institute, an average of 125 cases of bites were registered annually between 1997 and 2010, with a mortality rate of 0.91%. In Catalonia, only two fatal cases have been reported in the last 25 years. In Sweden, 5,141 snake bites were recorded between 1911 and 1944, resulting in 21 deaths.

D. González cites 250 cases between 1963 and 1978; 208 for viper, 10 for *Malpolon monspessulamus* and 32 for other non-poisonous snakes. He also reports personal experience with two deaths, derived from the treatment with anti-ophidic serum applied to four severe patients. He estimates the annual mortality rate for Spain at between three and seven cases, based on a national study conducted in 1975, and his personal experience with more than 125 cases treated. In a review of 27 patients admitted for snake bites in Soria, and 54 cases treated in seven hospitals in Aragon between 1992 and 1996, no serious cases occurred.

30-40% of bites have no venom (dry bites). The severity of the poisoning depends on the amount of poison injected, the patient's age and history.

The effects of the poison are grouped into three main categories: proteolytic, coagulant and haemolytic. Some authors add neurotoxic effects to the poisons of some species. The mechanism of action on coagulation occurs in several ways. Firstly, platelet aggregation consecutive to vascular injury, enhanced by the endopeptidase of the venom, causes activation of platelet factors. Secondly, activation of the prothrombin-to-thrombin and fibrinogen-to-fibrin switch. The end result is a consumptive coagulopathy. Activation of the complement and kinin systems is the main cause of oedema. The haemolytic effect is produced directly by the action of phospholipase A on the membrane of the erythrocyte, or through the transformation of lecithin into lysolecithin, which acts as a haemolytic substance. The neurotoxic effect has rarely been reported in snake bites. González describes two cases out of a total of 250, both by *V. aspis*.

Signs and symptoms

Local

- Pain that goes away gradually in a few minutes or hours.
- Oedema: the main sign of poisoning. It can be mild if it is only a local oedema, moderate when it affects the whole limb and severe if it extends beyond the root of the limb and can spread to the thorax and abdomen, becoming widespread. The appearance of an early oedematous reaction at a distance (tongue, larynx, lips) points to suspicion of a severe hypersensitivity reaction.
- Redness and bruising of the skin and bleeding blisters.

General

- Digestive disorders: nausea, vomiting, abdominal pain in 60% of cases.
- Neurological disorders: vertigo and headache in mild cases, convulsions, agitation, clouding and coma in severe cases.
- Mild cardiovascular disorders: hypotension, tachycardia in 60% of cases.
- Clotting disorders.

Table 11.4. Poisoning severity score

Severity grades	Symptoms or signs
0	• Simple bite without inflammatory reaction, likely to be a small snake or viper bite without venom inoculation
I	• Ecchymosis around the lesion • Progressive oedema in the proximal direction • Absence of general manifestations
II	• Intense local reaction • Oedema affecting the entire limb • Regional adenopathies • General mild symptoms (nausea, vomiting, etc.)
III	• Intense local reaction • Oedema that overflows the limb • Poor general condition • Clotting disorders • Neurological, cardiovascular or renal manifestations

Severe bites are usually those that affect children under the age of five and those that affect the face, neck and trunk. In Catalonia, the prevalence of this type of serious bite is estimated at approximately 50 cases per year, which are concentrated throughout the months of May to September.

The main complications are shock, pulmonary oedema, renal failure and the appearance of haemorrhages. Death is rare and occurs in children, the elderly, and people who are weakened or hypersensitive to the poison.

In the case of snakes, the clinical manifestations are paraesthesia, local oedema, palpebral ptosis, respiratory, speech and swallowing disorders.

Prevention of snake bites

- Wear high boots and thick trousers.
- In areas where there may be snakes, walk around making noise and avoid rocky areas, hot rocks from the sun and sunnier areas. At night, walk through clearings, avoiding forested areas.
- Do not put your hands in the holes of trees, caves or burrows.
- Do not lift stones or remove dry brush without precautions.
- Do not attempt to catch any snakes.
- Do not leave tents or sleeping bags open.

Treatment (C)

First of all, whether a snakebite really has occurred must be ascertained. In the case of the viper, two small wounds separated by one centimetre will be observed, and in the case of small snakes (*culebra* in Spanish), two rows of parallel or slightly divergent punctures.

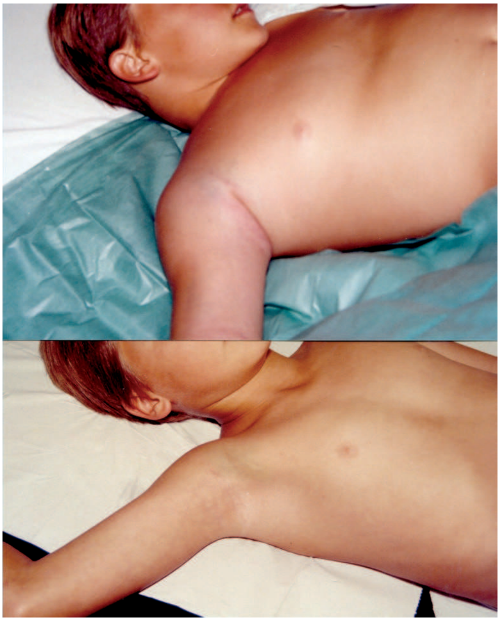


Figure 11.3. Viper bite grade III.

In the first few minutes, up to the first hour

- Remain calm and remember that many bites are poison-free and that the risk of serious problems is low. Do not get excited or run, the movement accelerates blood circulation and, therefore, the spread of any poison. Therefore, the injured person should be transported to hospital with as little effort as possible on his or her part.
- Suction is poorly effective. Large debridement (cuts) and tourniquets are contraindicated, as they can cause secondary infections and the poison to spread.
- Apply cold water for about 30 minutes. If a cold pack or local ice pack is applied, it should be wrapped in a cloth, not placed directly on the skin.
- Clean with plenty of water and soap. Apply antiseptics when possible, considering that the staining of the area due to the application of povidone-iodine may hinder control of the development of the lesion.
- Immobilise the affected area with a compressive bandage or splint, and keep it lower than the rest of the body to make it harder for venom to spread.[175]
- Analgesia can be administered with paracetamol or ibuprofen, avoiding acetylsalicylic acid.
- Transfer to the hospital.

Hospital treatment

Applying compresses soaked in Burow's solution for 15 minutes every 6 hours and then washing with hydrogen peroxide may reduce skin inflammation.

Assess whether antihistamines, corticosteroids (rapidly progressive oedema or respiratory disorders due to laryngeal oedema), heparin (particular risk of thromboembolism) and anti-ophidic serum are indicated.

Anti-ophidic serum is only used in grade III poisonings or exceptionally grade II poisonings where the intensity of the symptoms or their rate of progression presupposes severity. It is always applied in a hospital setting, as this serotherapy has a significant risk of serious reactions. If used, the Besredka method should be applied, consisting of progressive doses, with observation periods (0.1 mL of serum subcutaneously followed by a 15-minute break, then 0.25 mL subcutaneously and then another 15-minute wait). In the absence of reactions, the remainder (4.65 mL) is infused into the vein, dissolved in 500 mL of saline solution, within 4 hours.

Table 11.5. Snakebite treatment according to severity

Grade 0	• Observation for a minimum of 6 hours. • Check and clean the wound, making sure there are no pieces of fang left. • Verify tetanus vaccination. • Assess antibiotic therapy (amoxicillin with clavulanic acid or, in case of allergy, erythromycin or clindamycin). • Analgesia with paracetamol 650-1,000 mg every 6-8 hours.
Grade I	• Observation for 6-12 hours for monitoring progress (oedema, neurological and blood disorders). • The rest as in grade 0.
Grade II	• Admission for better control. • It may require surgical debridement of the lesions or anti-ophidic serum. • The rest as in grade I.
Grade III	• Anti-ophidic serum. • Transfer to intensive care unit. • The rest as in grade II.

12

POISONING BY PLANTS[176, 177, 178]

Usually caused by accidental ingestion when they are mistaken for edible plants, they are also reported in children and people with psychiatric disorders. In Spain, the number of consultations with the Toxicological Information Service on plant poisonings is increasing (164 in 1994; 700 in 2001) and in the United States 100,000 cases are reported annually, most of them mild. Do not eat plants that are unknown, because a good number of berries, leaves and fruits are very poisonous.

Poisoning from wild berries often leads to vomiting and diarrhoea. Treatment consists of gastric lavage, treatment of symptoms and measures to maintain cardiorespiratory activity.

ACONITUM NAPELLUS (BLUE) AND *ACONITUM VULPARIA* (YELLOW)[179]

Overview

Castilian (Spanish): acónito, napelo, vedagambre, matalobos.
Catalan: tora, acònit, matallops.
Euskera (Basque): otseri, irabelarr.
Galician: napello, capuz.
Portuguese: acónito.
French: aconit de napel, coqueluchon, casque de Jupiter.
English: blue/yellow monkshood, blue/ yellow aconite, wolfsbane.
Italian: acónito.
German: Blauer Eisenhut, Echter Sturmhut.

It is abundant in the Pyrenees and Pre-Pyrenees. It is considered the most toxic plant in Europe. The most important active ingredient in the aconite is aconitine, the most toxic of all alkaloids; a dose of 1 mg can be lethal. There are numerous anecdotes relating to deaths caused by accidental ingestion, such as the case of some shepherds from Setcases (Eastern Pyrenees) who, when roasting birds using aconite stems, died on the spot; the case of a company of French parachutists who died in 1960 during survival exercises in the Central Pyrenees while eating aconite roots; or the case of a family who confused aconite with wild celery (Pyrenean celery: *Molopospermum peloponnesiacum*), with some of the members dying despite the promptness

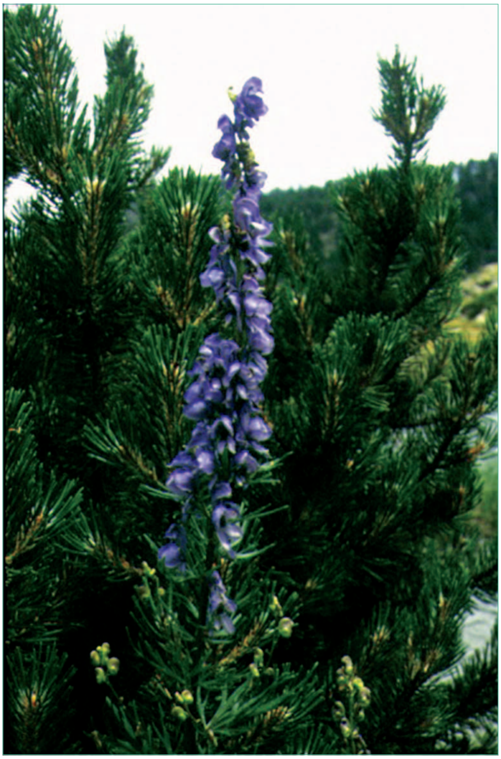


Figure 12.1. Blue *Aconitum*.

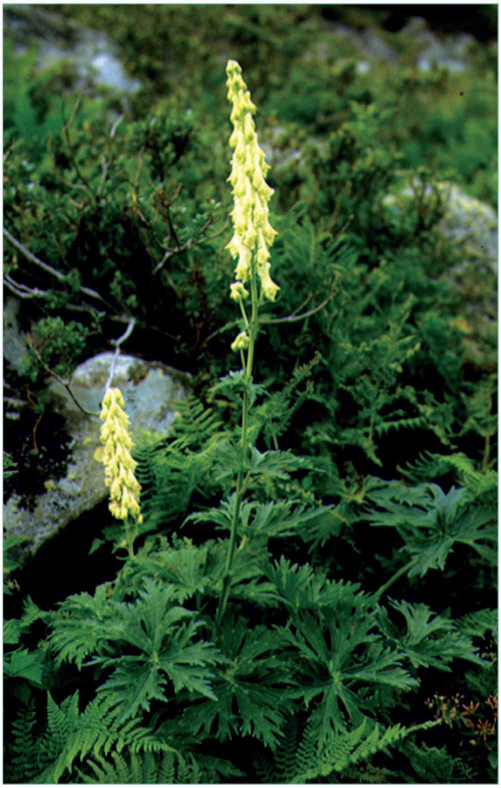


Figure 12.2. Yellow *Aconitum*.

of the treatment. Its effects are startling, it seems that 3 mg sprayed into the eye of a horse is enough to kill it. The Spanish National Toxicological Information Service has received 18 notifications of aconite poisoning in the last 8 years.180

Signs and symptoms

- Neurological: sensory, after 5-25 minutes, tingling in the mouth and lips that extends to the extremities; motor muscle weakness in the extremities.
- Cardiovascular: hypotension, chest pain, palpitations, bradycardia, tachycardia, ventricular extra systoles, tachycardia and ventricular fibrillation.
- Gastrointestinal: nausea, vomiting, abdominal pain, diarrhoea.
- In-hospital mortality is 5.5% and is caused by asystole and treatment refractory ventricular arrhythmias.

Treatment (C)

- Transfer to the hospital.
- Measures to maintain cardiorespiratory activity. Inotropic drugs for hypotension and atropine for bradycardia may be helpful. Amiodarone or flecainide may be helpful as first-line antiarrhythmics. Cardiopulmonary bypass may be helpful in cases of cardiogenic shock and first-line treatment refractory ventricular arrhythmias.
- The usefulness of activated carbon is not well established.

ATROPA BELLADONA[181]

Overview

Castilian (Spanish): belladona, mandrágora, solano furioso.
Catalan: belladona, tabac bord.
Euskera (Basque): belaikina, baladar.
Galician: beladona.
French: morelle furieuse, mandragore, belle dame.
English: deadly nightshade, mandrake.
Italian: sanguina.
German: roter Hartriegel.

It is a perennial, ramified-stem plant that forms a thick bush and grows on the edge of broadleaf forests, among debris and in abandoned places. Cases of intoxication have been observed when its black berry is confused with blueberries. The intake of 3 berries in children and 10 in adults can be lethal. The main alkaloid is l-hiosciamine and, to a lesser extent, atropine and scopolamine.

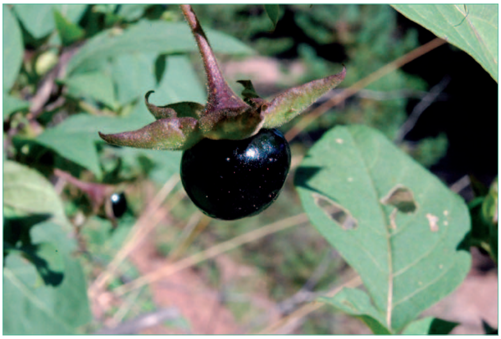


Figure 12.3. *Atropa belladona.*

Signs and symptoms

- Nausea, vomiting.
- Dry skin and mucous membranes (mouth, eyes), redness of the face, mydriasis, confusion, delirium, agitation and coma.
- Tachycardia.
- Death.

Treatment (C)

- Transfer to the hospital.
- Measures to maintain cardiorespiratory activity.
- Gastric lavage with subsequent administration of activated charcoal.
- Symptomatic treatment.
- Antidote: Physostigmine 1-2 mg in 1-2 min, which may be repeated until symptoms of agitation subside. If they reappear, you can administer it as a continuous infusion (2 mg in 500 cm^3 of 5% glycated serum to be infused in 12 hours) or in 0.2-0.5 mg boluses by slow IV in 5 minutes, this dose can be repeated after 30 and 60 minutes if neurological symptoms persist. The maximum dose is 4 mg/h. Side effects: bradycardia, hypotension and seizures. If these side effects occur, they can be counteracted with atropine at a dose of 0.5 mg per mg of physostigmine.

BRYONIA DIOICA

Overview

Castilian (Spanish): nueza, nudago, tuca, anorza, brionia, alfesira.
Catalan: carbassina, nap coent, tuca, briònia.

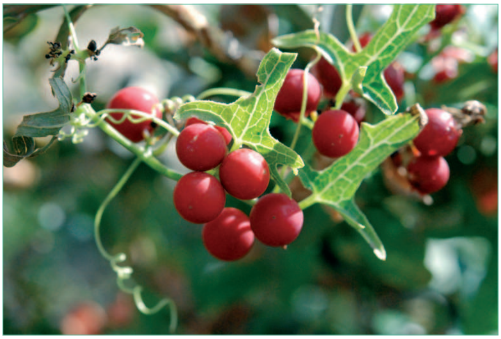


Figure 12.4. *Bryonia dioica.*

Euskera (Basque): asta matz, indarrgoi.
Galician: briònia, anora, nabo de nouza, nabo do diablo, herba papeira.
French: bryonie, navet du diable, vigneblanche, colubrine.
English: red/white bryony, ladies' seal, or English mandrake.
Italian: vite bianca.
German: rotbeerige Zaunrübe, gichtrúbe.

It is a vivacious herb whose fruit is a red berry. It grows on forest margins and banks. It contains a glycoside called brionin. Intake of 15 berries can kill a child, and 40 berries can kill an adult.

Signs and symptoms

- Nausea, vomiting, bloody diarrhoea
- Cramps, convulsions, coma, death
- Plant juice can cause skin lesions

Treatment (C)

- Transfer to the hospital
- Measures to maintain cardiorespiratory activity
- Induce vomiting with ipecac syrup or perform gastric lavage with subsequent administration of activated charcoal
- Symptomatic treatment.

COLCHICUM AUTUMNALE[182, 183]

Overview

Castilian (Spanish): cólquico, azafrán silvestre, mataperros, narciso de otoño.
Catalan: còlquic.
Euskera (Basque): azpesarr.
French: colchique, safran des prés, veilleuse.
English: tuberoot, autumn crocus, meadow saffron or naked ladies.
Italian: zafferano silvestre.
German: Herbstzeitlose, Wiesensafran.

A herbaceous plant containing two alkaloids. It grows in the meadows of the Pyrenees and Pre-Pyrenees. The intake of 5-10 seeds can be fatal; it is called 'vegetable arsenic'.

Signs and symtoms

- Latent period: 2-6 hours.

Colchicum autumnale

- Castilian (Spanish): cólquico, azafrán silvestre, mataperros, narciso de otoño.
- Catalan: còlquic.
- Euskera (Basque): azpesarr.
- French: colchique, safran des prés, veilleuse.
- English: tuberoot, autumn crocus, meadow saffron or naked ladies.
- Italian: zafferano silvestre.
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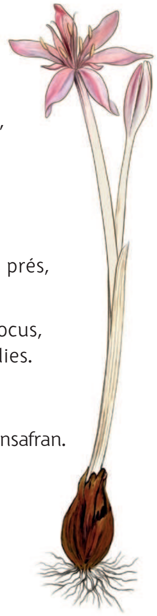


Figure 12.5. *Colchicum autumnale*.

- Burning mouth, dizziness, vomiting, abdominal pain, bloody diarrhoea.
- Headache, cramps, delirium, convulsions.
- Tachycardia, hypotension.
- Death in 90% of cases.

Treatment (C)

- Transfer to the hospital.
- Measures to maintain cardiorespiratory activity.
- Induce vomiting with ipecac syrup or perform gastric lavage with subsequent administration of activated charcoal.
- Symptomatic treatment.

CONIUM MACULATUM

Overview

Castilian (Spanish): cicuta, perejil lobuno, ceguda.
Catalan: cicuta, ciguda, julivertassa, fonoll de bou, julivert de galàpet.
Euskera (Basque): otzarri-belar, apo-perrexil.
Galician: cicuta, prixel das bruxas, pé do sapo, cegude, angariha malhada.
Portuguese: cicuta, cegude.
French: cigüe, fenouil sauvage.
English: hemlock, poison hemlock.
Italian: cicuta Maggiore.
German: gefleckter Schierling.

It grows by streams and roadsides. Contains several alkaloids. Poisoning occurs when its leaves are confused with parsley, or its root with parsnips; its unpleasant smell helps to differentiate it correctly. Its toxicity is well known because it was the cause of death of the philosopher Socrates. Cases of human intoxication from eating partridges that had eaten hemlock have been reported.

Signs and symtoms

- Burning mouth, dizziness, vomiting and diarrhoea.
- Mydriasis, visual difficulty, hallucinations, muscle pain, progressive paralysis.
- Kidney failure. The urine gives off a characteristic smell of bitter almonds.
- Death from respiratory arrest in 3-4 hours. If treated early, the mortality rate is less than 10%.

Treatment (C)

- Transfer to the hospital.
- Measures to maintain cardiorespiratory activity.
- Induce vomiting with ipecac syrup or perform gastric lavage with subsequent administration of activated charcoal.
- Forced diuresis.
- Symptomatic treatment.

CORIARIA MYRTIFOLIA[184]

Overview

Castilian (Spanish): roldón, emborrachacabras.
Catalan: roldor, herba sabatera, emborratxacabres.
French: carroyère a feuille de myrte, redoul, redous.
Italian: stinco, rodo.
English: redoul
German: Gerberstrauch.

Treatment (C):
- Transfer to the hospital.
- Measures to maintain cardiorespiratory activity.
- Gastric lavage with subsequent administration of activated charcoal.
- Forced diuresis.
- If there are seizures, diazepam may be used.
- Symptomatic treatment.

Coriaria m yrtifolia

- Castilian (Spanish): roldón, emborrachacabras.
- Catalan: roldor, herba sabatera, emborratxacabres.
- French: carroyère a feuille de myrte, redoul, redous.
- Italian: stinco, rodo.
- English: redoul
- German: Gerberstrauch.

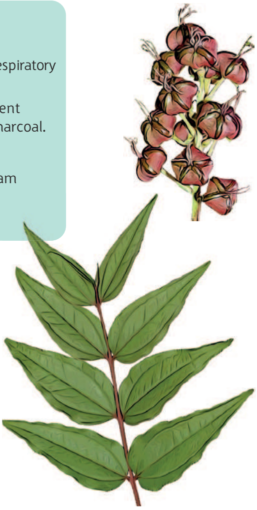


Figure 12.6. *Coriaria myrtifolia.*

It's a bush that grows on the margins. Its fruit is a reddish berry containing the glucoside coriamirtine. Poisoning occurs when it is confused with blackberries (*Rubus ulmifolius*), as happened to eight children in Terrassa, one of whom died. Cases of intoxication from eating snails or partridges that had ingested redoul have been reported. The intake of 15-20 berries can be lethal for an adult.

Signs and symtoms

- Latency period of 30-120 minutes.
- Nausea, vomiting, bloody diarrhoea, dry mouth.
- Dizziness, headache, agitation, convulsions lasting 5-10 minutes, repeated every 10-30 minutes, coma.
- Dyspnoea.
- Death from cardiac arrest in 15% of cases.

Treatment (C)

- Transfer to the hospital.
- Measures to maintain cardiorespiratory activity.
- Gastric lavage with subsequent administration of activated charcoal.
- Forced diuresis.
- If there are seizures, diazepam may be used.
- Symptomatic treatment.

DAPHNE MEZEREUM

Overview

Castilian (Spanish): mezereon, laureola hembra, leño gentil.
Catalan: tintorell, olivella, herba dels fics, olivereta, mezèreon.
Euskera (Basque): ario, erenoski, saradona, sorrburu, ezeinuntztxo, tartiku velar.
French: daphné marillon, bois joli.
English: February daphne, mezereon, mezereum, spurge laurel, or spurge olive.
Italian: camelea, mezzereo.
German: gemeiner Seidelbast, Kellerhals, Ziland.

It is a bush that produces a red berry. It is found in fir, beech and oak forests. The intoxication is due to his confusion with gooseberries. An intake of 10-15 berries can kill a child.

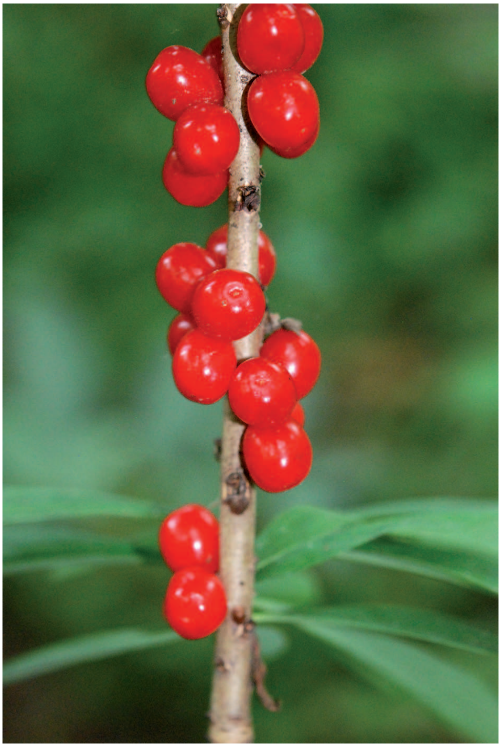


Figure 12.7. *Daphne mezereum.*

Signs and symptoms

- Burning mouth, abdominal pain, nausea and diarrhoea.
- Fever, dizziness, respiratory distress.
- Death in 30% of cases.

Treatment (C)

- Transfer to hospital.
- Measures to maintain cardiorespiratory activity.
- Induce vomiting with ipecac syrup or perform gastric lavage with subsequent administration of activated charcoal.
- Symptomatic treatment.

DATURA STRAMONIUM[185]

Overview

Castilian (Spanish): estramonio, hediondo, mata del infierno, berenjena del diablo, burladora, chamico, perines, trompetilla.
Catalan: estramoni, orval, herba talpera, herba de l'ofec, figuera d'infern, herba pudent.
Euskera (Basque): pikozoro.
Galician: figueira do inferno.
Portuguese: estramonio.
French: stramoine, pomme épineuse, herbe du diable.
English: jimsonweed, devil's snare, thorn apple; among other names.
Italian: stramonio, noce spinosa.
German: Stechapfel.

A herbaceous plant that grows by streams or on riverbanks and embankments. The main alkaloid is l-hyoscyamine, and to a lesser extent atropine and scopolamine. The intake of about 20 seeds can be deadly.

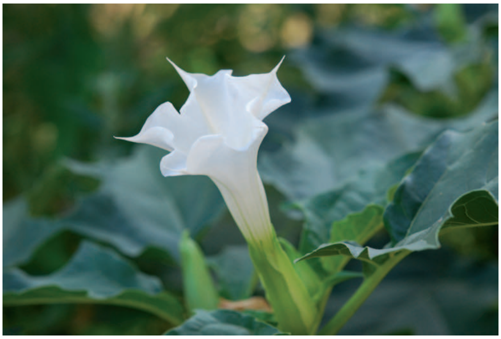


Figure 12.8. *Datura stramonium.*

Signs and symptoms

- Nausea, vomiting.
- Dry skin and mucous membranes (mouth, eyes), redness of the face, mydriasis, confusion, delirium, agitation and coma.
- Tachycardia.
- Death.

Treatment (C)

- Transfer to hospital.
- Measures to maintain cardiorespiratory activity.
- Induce vomiting or perform gastric lavage with subsequent administration of activated charcoal.
- Symptomatic treatment.
- Antidote: Physostigmine 1-2 mg in 1-2 min, which may be repeated until symptoms of agitation subside. If they reappear, you can administer a continuous infusion (2 mg in 500 cm^3 of 5% dextrose solution to be infused within 12 hours) or in 0.2-0.5 mg boluses by slow IV in 5 minutes, this dose can be repeated after 30 and 60 minutes if neurological symptoms persist. The maximum dose is 4 mg/h. Side effects: bradycardia, hypotension and seizures. If these side effects occur, they can be counteracted with atropine at a dose of 0.5 mg per mg of physostigmine.

HEDERA HELIX[186]

Overview

Castilian (Spanish): hiedra.
Catalan: heura.
Euskera (Basque): txira, untzi, txirosto, zuzkei.
Galician: her, hereira, hédera.
Portuguese: hédera.
French: lierre grimpant.
English: common ivy, English ivy, European ivy, or just ivy.
Italian: edera.
German: Efeu.

It is a liana that can be found in all kinds of forest habitats, rocky areas, walls, etc. Its toxic-

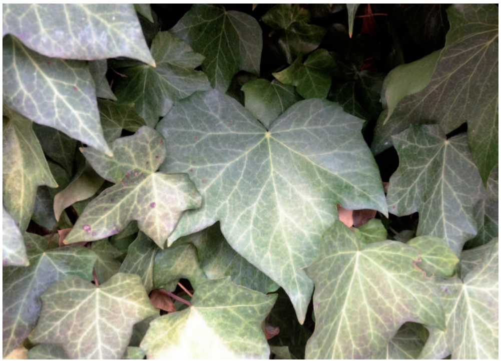


Figure 12.9. *Hedera helix.*

ity is due to the high content of saponosides. The fruit contains a glycoside and an alkaloid and the leaves contain calcium oxalate crystals. 50 cases of intoxication were reported between 1976 and 1981, some of them fatal. The lethal dose for a child is 3 berries.

Signs and symptoms

- Prostration, fever, diarrhoea, vomiting.
- Muscle spasms, seizures, paralysis, coma
- Death by respiratory arrest.

Treatment (C)

- Transfer to the hospital.
- Measures to maintain cardiorespiratory activity.
- Induce vomiting with ipecac syrup or perform gastric lavage with subsequent administration of activated charcoal.
- Symptomatic treatment.

LONICERA XYLOSTEUM

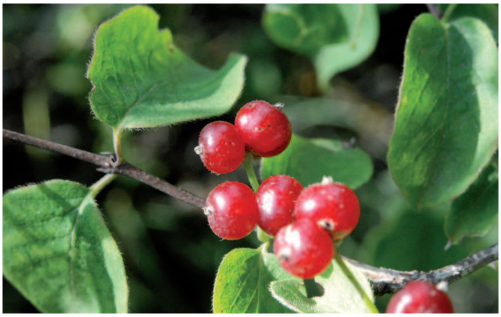


Figure 12.10. *Lonicera xylosteum.*

Overview

Castilian (Spanish): madreselva roja de los Pirineos.
Catalan: xuclamel xilosti.
Euskera (Basque): atxaparra.
Galician: madressilva.
English: fly/dwarf honeysuckle or fly woodbine.
Italian: gisilostio.
German: gemeine Heckenkirsche.

It is a bush that produces red berries. It grows on the margins and boundaries of forests. Symptoms appear from the intake of 30 berries.

Signs and symptoms

- Vomiting and diarrhoea.
- Arrhythmias, convulsions, coma and death.

Treatment (C)

- Transfer to the hospital.
- Measures to maintain cardiorespiratory activity.
- Induce vomiting with ipecac syrup or perform gastric lavage with subsequent administration of activated charcoal.
- Symptomatic treatment.

NERIUM OLEANDER[187]

Overview

Castilian (Spanish): adelfa, nerio, aloendro, laurel rosa.
Catalan: baladre, llorer rosa, oleandre, diva.
Euskera (Basque): eroitzori, epriot-orri.
Galician: neiro, loendro, adelfa, lendreira.
Portuguese: loendro, adelfa.
French: nerión.
English: nerium, nerium oleander.
Italian: oleandro.
German: Oleander.

It is a bush rich in glycosides. It is found by streams on the southern Mediterranean coast.

Signs and Symptoms

- Nausea, vomiting, diarrhoea (sometimes bloody), abdominal pain.
- Headache, balance disturbances, drowsiness, coma.

Nerium oleander

- Castilian (Spanish): adelfa, nerio, aloendro, laurel rosa.
- Catalan: baladre, llorer rosa, oleandre, diva.
- Euskera (Basque): eroitzori, epriot-orri.
- Galician: neiro, loendro, adelfa, lendreira.
- Portuguese: loendro, adelfa.
- French: nerión.
- English: nerium, nerium oleander.
- Italian: oleandro.
- German: Oleander.

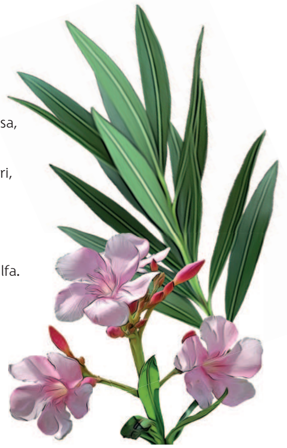


Figure 12.11. *Nerium oleander.*

- Cardiac arrhythmias. Cardiac arrest.

Treatment (C)

- Transfer to the hospital.
- Measures to maintain cardiorespiratory activity.
- Induce vomiting with ipecac syrup or perform gastric lavage with activated charcoal.[188]
- Antidote: The administration of purified FAB fragments of anti-digoxin antibodies at doses of 80-120 mg may be useful. IV within 20 sec after a skin sensitivity test.[189]

RICINUS COMMUNIS[190]

Overview

Castilian (Spanish): catapucia, ricino, higuera infernal.
Catalan: ricí, figuera infernal.
Euskera (Basque): akain-belarr.
Galician: erva dos carrapatos.
French: ricin, palma christi.
English: castor bean or castor oil pant.
Italian: ricino, palmacriste.
German: Ricinus, Wunderbaum, Christuspalme.

It is a bush. The main alkaloid is ricin, a potent inhibitor of protein synthesis. Chewing 3 seeds in a child or 10 seeds in an adult can result in death; a review of 424 cases found an overall mortality of 8%.

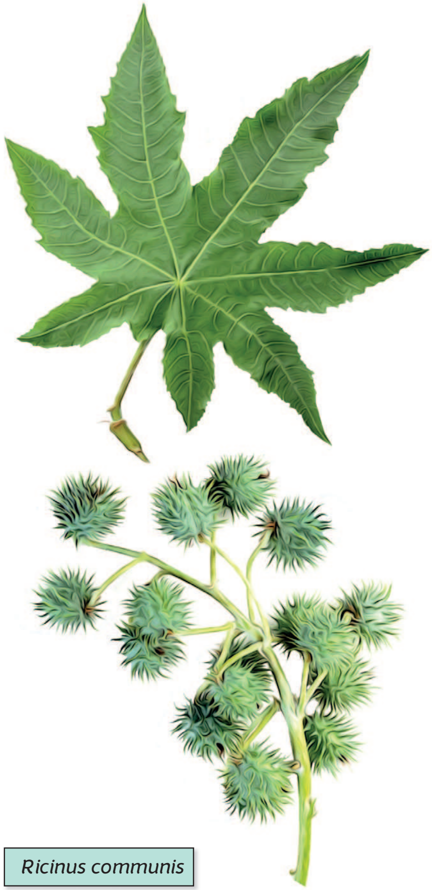


Figure 12.12. *Ricinus communis.*

Signs and symptoms

- Nausea, vomiting, choleriform diarrhoea, abdominal pain.
- Seizures, liver cell destruction, haemolysis, kidney failure.

Treatment (C)

- Transfer to the hospital.
- Measures to maintain cardiorespiratory activity.
- Induce vomiting with ipecac syrup or perform gastric lavage with subsequent administration of activated charcoal.
- Symptomatic treatment.

URTICA URENS AND *URTICA DIOICA*

Overview

Castilian (Spanish): ortiga, picamoscas, picasarna.
Catalan: ortiga.
Euskera (Basque): asuin.
Galician: urtiga, estruga.
French: ortie.
English: annual/dwarf/small/dog/burning nettle and common/stinging nettle.
German: Brennnessel.

Herbaceous plant with stinging hairs.

Signs and symptoms

- Skin contact causes pain and hives.
- Ingestion may cause heavy salivation, vomiting and arrhythmias.

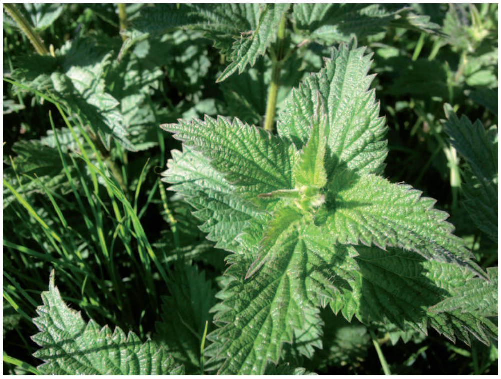


Figure 12.13. *Urtica urens.*

Treatment of skin lesions (C)

- Wash with plenty of water.
- An antihistamine (cetirizine, ebastine, loratadine) or a topical corticosteroid (hydrocortisone 1%) may be administered.

13

MUSHROOM POISONING[191, 192]

INTRODUCTION

Of the more than 5,000 varieties of mushrooms that exist, about a hundred can be toxic. Between 200 and 400 cases of mushroom poisoning are treated annually in Spain, of which 0.2-0.3% are serious and 0.03% die.[193]

CLINICAL PRESENTATION

Poisonings are classified according to their incubation period:

- Less than 6 hours.
- Between 6 hours and 3 days (usually more severe, can injure vital organs).

Short incubation syndromes (<6 hours)

Pure gastrointestinal syndrome

Clinical presentation: acute gastroenteritis without liver failure.

Toxins: gastrointestinal irritants.

Appearance of symptoms: <6 hours (most within the first 3 hours).

Examples: *Chlorophyllum molybdites, Clitocybe nebularis, Omphalates illudens.*

Treatment: supportive treatment, fluid replenishment as needed.

Mortality: rarely fatal, symptoms usually resolve within the first 6 hours.

Delusional syndrome

Clinical presentation:: excitement and depression of the central nervous system: stupor, coma, delirium, agitation, hallucinations and convulsions in children.

Toxins: ibotenic acid, muscimol.

Appearance of symptoms: 30 minutes to 2 hours.

Examples: *Amanita muscaria, A. pantherina, A. gemmata.*

Treatment: supportive treatment. Benzodiazepines without agitation (e.g. lorazepam 0.05 mg/kg, maximum dose 2-4 mg).

Mortality: rarely fatal, symptoms usually resolve within the first 6-24 hours.

Hallucinogenic syndrome

Clinical presentation: hallucinations

Toxins: psilocybin, psilocin.

Appearance of symptoms: 30 minutes to 2 hours.

Examples: *Psilocybe cubensis, P. mexicana, Conocybe cyanopus, Gymnopilus aeruginosa, Panaeolousfoenisecil, Conocybe cyanopus.*

Treatment: supportive treatment. Benzodiazepines in case of agitation (e.g. lorazepam 0.05 mg/kg, maximum dose 2-4 mg).

Mortality: rarely fatal, symptoms usually resolve within the first 12 hours.

Muscarinic or cholinergic syndrome

Clinical presentation: vomiting, diarrhoea, bradycardia, bronchorrhea, bronchospasm, salivation, tearing.

Toxins: muscarin.

Appearance of symptoms: 30 minutes to 2 hours.

Examples: *Clitocybe dealbata, Clitocybe illudens, Inocybe fastigiata, Boletus calopus.*

Treatment:

- Supportive treatment: fluid replacement to compensate for vomiting and diarrhoea losses. Persistent vomiting may be treated with ondansetron 0.15 mg/kg IV.
- Atropine (0.02 mg/kg IV, minimum dose 0.1 mg, maximum dose 1 mg) or glycopyrrolate (10 µg/kg, maximum dose 0.2 mg). Repeat as needed until the bronchial secretions have dried up.

- Bronchospasm can be treated with salbutamol combined with ipratropium bromide if necessary.
- Mortality: rarely fatal, symptoms usually resolve within the first 12 hours.

Coprinus syndrome

Clinical presentation: disulfiram-like reaction (flushing, headache, tachycardia, chest pain, anxiety). Toxicity appears when ingestion is associated with the consumption of alcoholic beverages between 3-4 hours prior to ingestion and 2-3 days after ingestion.

Toxins: cuprine. It interferes with the oxidative mechanism of ethanol by inhibiting the enzyme alcoholholdeshydrogenase, accumulating acetaldehyde in the blood.

Appearance of symptoms: 30 minutes to 2 hours.

Examples: *Coprinus atramentarius, Clitocybe clavipes.*

Treatment: supportive treatment.

Mortality: rarely fatal, symptoms usually resolve within the first 6 hours.

Hemolytic syndrome

Clinical presentation: immune-mediated hemolytic anemia.

Toxins: antibodies against Paxillus involutus.

Appearance of symptoms: ingestion of cooked mushrooms more than once.

Examples: *Paxillus involutus.*

Treatment: supportive treatment. May develop kidney failure.

Mortality: rare.

Syndromes of long incubation (>6 hours)

Phalloid or cyclopeptide syndrome[194 195]

Clinical presentation: liver toxicity and late gastroenteritis.

- Latency phase: asymptomatic, lasts between 6-12 hours.
- Coleriform phase: severe sudden onset gastroenteritis with diarrhoea, vomiting and abdominal pain. Dehydration can lead to kidney failure.
- At 24-48 hours the patient apparently improves, possibly due to the treatment of dehydration, but between the 3rd and 5th day the general condition worsens and signs and symptoms of hepatic and renal failure appear with neurological involvement, ascites and coagulopathy, that progress rapidly towards coma and death.
- If this episode is overcome, by the fifth day, recovery with normalisation of liver function begins, and chronic liver disease may remain as a consequence.

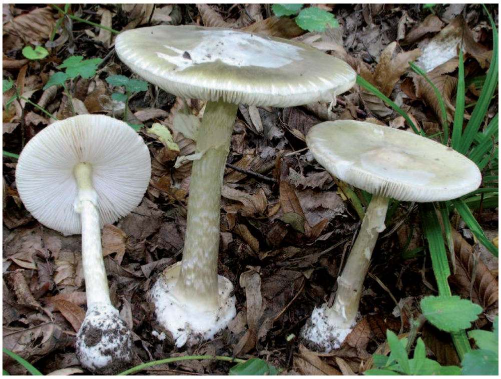


Figure 13.1. *Amanita phalloides.*

Toxins: cyclopeptides: anatoxins, phalotoxins.

Appearance of symptoms: 6-24 hours.

Examples: *Amanita phalloides, A. virosa, A. verna, A. bisporigera, Galerina autumnalis, G. marginata, G. venenata, Lepiota helveola.*

Treatment (C)[196]

- Is started urgently, even before obtaining analytical confirmation (amatoxin in urine or gastric aspirate).
- Multiple doses of activated charcoal: 1-2 g/kg initially followed by 0.5-1 g/kg every 2-4 hours to interrupt enterohepatic circulation of amatoxins (B).
- Silibinin 20 mg/kg/day has been used to prevent the entry of amanitins into the hepatic cells, distributed over 4 IV infusions of 2 hours duration each and with 4 hour intervals between them, controlling the fluid balance. Together with N-acetylcysteine it is an effective therapy.
- N-acetyl cysteine:
  - Intravenous use: initial dose of 150 mg/kg in 15 minutes. Subsequently, 50 mg/kg in 4 hours and, finally, 100 mg/kg in 16 hours.

  - Oral: initial dose 140 mg/kg, followed by 70 mg/kg every 4 hours for 17 doses.
- In order to remove the toxins from their bonding sites and to favour their excretion, it has been suggested to use penicillin G sodium IV 200-300,000 IU/ kg/day every 4 hours for 4 days. It is not very effective.
- Supportive treatment: IV fluid replacement for cholera-like gastroenteritis.
- Treatment of liver failure and hepatorenal syndrome.
- Liver transplantation.

Mortality: 2-60%.[197]

Gyromitrin syndrome

Clinical presentation: seizures, late gastroenteritis and hepatotoxicity.

Toxins: gyromitrin.

Appearance of symptoms: 4-10 hours.

Examples: *Gyromitra esculenta, G. infula, Sarcosphaera coronaria y Cyathipodia macropus.*

Treatment:

- Seizures: benzodiazepines and pyridoxine (70 mg/kg IV, maximum dose: 5 grams) Methemoglobinemia: methylene blue (1-2 mg/kg IV, slowly infused for more than 5 minutes) if methemoglobin level is above 20 % or causes symptoms.
- Supportive treatment: IV fluid replacement for late vomiting and diarrhoea.

Mortality: 0-10 %.

Orellanine syndrome

Clinical presentation: late renal failure.

Toxins: orellanine, orellinine, curtainarin.

Appearance of symptoms: 3-20 days.

Examples: *Cortinarius orellanus, C. speciosissinus, Mycena pura, Omphalatus orarius.*

Treatment:

- Supportive.
- Haemodialysis in case of renal failure.
- Renal transplantation (13%).

Mortality: rare. End-stage renal failure 11%.

Rhabdomyolysis associated with the consumption of Tricholoma equestre

Clinical presentation: rhabdomyolysis within 1 to 3 days of intake, with the triad of granular pigmented cylinders in the urine, red-brown color of the urine and elevation of creatine kinase (CK) in the plasma.

Toxins: unknown.

Appearance of symptoms: 24-72 hours.

Examples: *Equestrian tricholoma.*

Treatment.

- Replacement of fluids with a saline solution (20 to 40 mL/kg/h, up to 1 to 2 litres per hour) to maintain a minimum urine flow of 4 mL/kg per hour, 200 mL per hour in adults. Alkalinisation of urine or use of mannitol to increase urine output may be associated with adverse effects and the efficacy of these strategies is controversial.
- Treatment of hydroelectrolyte disorders: hyperkalaemia, hyperphosphatemia and hypocalcaemia. Hypocalcemia is usually transient and calcium should be avoided if there are no severe symptoms (e.g. tetanus).
- Hemodialysis.

Mortality: 25%.

GENERAL MANAGEMENT

Overview

- Initial assessment, airway support, breathing and circulation.
- Identification of the mushroom and toxin. Consultation with the national toxicology centre (Spain: +34 91 5620420) may be helpful. If the mushrooms are identified, the treatment is based on it, if they cannot be identified, base the treatment on clinical practice. If no sample of ingested mushrooms is available, nasogastric aspiration can be used to identify the fungus.
- Hydroelectrolyte correction.
  - Control and replacement of fluid and electrolyte losses due to vomiting and diarrhoea.
  - Vomiting and diarrhoea: these are common and can be caused by any type of mushroom. Anti-emetics do not increase the absorption of toxins (e.g. ondansetron 0.15 mg/kg IV). Avoid antispasmodics (loperamide) in case of diarrhoea.
- Gastrointestinal decontamination.

  - Activated charcoal is recommended for conscious patients within the first hour of taking potentially toxic mushrooms. Multiple doses of activated charcoal can decrease the circulation of amatoxins.
  - Gastric lavage beyond the first hour of its ingestion is not recommended due to its dubious efficacy, nor is the administration of ipecac syrup in an Accident and Emergency Department **(B)**. Syrup of ipecac can be administered in remote locations to decrease toxicity.
- Determine liver and kidney function.

Although potentially lethal fungi usually produce symptoms beyond 6 hours after their consumption, the presence of symptoms before 6 hours does not exclude severity, especially when more than one type of mushroom has been eaten.

Agitation

Mushrooms containing psilocybin, psilocine, muscimol or ibotenic acid can cause hallucinations. Benzodiazepines (e.g. midazolam 0.05 mg/kg or lorazepam 0.05 to 0.1 mg/kg) may be administered. Physostigmine should be avoided as excitation of the CNS is not caused by anticholinergic effects.[191]

Seizures

Mushrooms containing gyromitrin, muscimol or ibotenic acid can cause seizures. Treatment consists of oxygenation, airway and breathing support, and administration of benzodiazepines (e.g. lorazepam 0.05 to 0.1 mg/kg). In patients who have ingested mushrooms with gyromitrin, or if the seizures are not controlled with benzodiazepines, pyridoxine (e.g. 70 mg/kg IV up to 5 g) may be administered together with benzodiazepines. Pyridoxine reverses pyridoxal-5-phosphate deficiency in the central nervous system mediated by the toxic metabolite monomethylhydrazine.

Liver failure

Patients with signs of liver toxicity, or whose symptoms appear 6 hours after mushroom ingestion have a high risk of acute liver failure from mushrooms with anatoxin or gyromitrin. They can present serious complications such as encephalopathy, cerebral oedema, sepsis, renal insufficiency, circulatory insufficiency, coagulopathy, gastrointestinal haemorrhages and metabolic alterations such as metabolic acidosis, hypoglycaemia and hypophosphatemia. They should therefore be transferred to a facility with an intensive care unit and a liver transplant programme before severe coagulopathy or increased intracranial pressure develops.

Renal failure

Intake of mushrooms containing orellanin may lead to late renal failure. The main complications of renal failure are volume overload, hyperkalaemia, metabolic acidosis, hypocalcemia and hyperphosphatemia. The initial evaluation includes the evaluation of hydration, serum electrolytes, especially potassium and bicarbonate, blood count, serum phosphate, calcium, albumin and uric acid.

The indications for dialysis are:

- Fluid overload that is resistant to diuretics
- Hyperkalemia >6.5 mEq/L or rapid increase in serum potassium, as may occur in rhabdomyolysis.
- Metabolic acidosis (pH <7.10) in patients with volume overload, which is aggravated by the administration of sodium bicarbonate, or with lactic acidosis, which is generally not treated with bicarbonate.
- Signs of uraemia, such as pericarditis, neuropathy, or unexplained mental decline.

Criteria for admission to hospital

- Patients with late symptoms more than six hours after mushroom ingestion.
- Patients with early symptoms less than three hours after ingestion of mushrooms that remain symptomatic for more than six hours despite supportive treatment, or that have ingested more than one type of fungus.
- Patients with evidence of rhabdomyolysis, liver toxicity, kidney failure.
- Asymptomatic patients with suspected intake of amatoxin-containing mushrooms.

- Asymptomatic patients who cannot be guaranteed 24-hour extra hospital follow-up.
- Asymptomatic patients who can be assured of a 24-hour follow-up can be discharged.
    - Patients whose first symptoms resolve and in whom the intake of late toxic mushrooms can be reliably excluded based on history, clinical manifestations and, where possible, with the identification of fungi, may also be discharged with follow-up by telephone or in person within 24 hours.

RECOMMENDATIONS TO PREVENT MUSHROOM POISONING

- Collect only those edible species that can be indisputably identified.
- There is no reliable home test to ensure the edibility of mushrooms (blackening of garlic or silver, mushrooms eaten by animals, etc.).
- Do not pick mushrooms that have started to decompose, have become frozen, mouldy, or are soaked in water.
- Transport the mushrooms in rigid and well-ventilated containers to avoid fermentation.
- Eat them as soon as possible and well cooked, meanwhile keep them in the refrigerator.
- Consume them in moderation, preferably as an accompaniment.

In case of poisoning:

- Go to a hospital immediately.
- Take the leftovers of the mushrooms eaten.
- If the mushrooms have been consumed by several people, asymptomatic people should also go to the hospital.

TECHNIQUES USED IN THE TREATMENT OF POISONING

Gastric lavage technique

- In unconscious people, the airway should be protected by endobronchial intubation.
- Gastric aspiration should be performed prior to flushing.
- Large gauge probes with holes in the tip are used to prevent clogging when solid debris is recovered.
- The patient is placed in the left lateral position and in the Trendelenburg position.
- 300 mL of water or physiological saline solution are introduced each time at a temperature of 45 ºC and the aspiration is repeated 10 times until the liquid comes out clear.

Activated charcoal

- Activated charcoal has a high absorption capacity and can therefore reduce the passage of toxic substances from the stomach into the blood.
- It is only effective when administered within minutes after ingestion of the poison. If given one hour after ingestion of the poison, or when the stomach contains food, its effectiveness is poor.
- It is contraindicated when there is a risk of pulmonary aspiration or when there is an intention to subsequently administer an antidote or syrup of ipecac to provoke vomiting, as the carbon will inactivate the antidote or syrup of ipecac.
- Dosage: 50 g of activated charcoal in 300 mL of water. For very toxic products, add 25 g of sodium sulphate.
- In enterohepatic circulation toxins, administer 50 g of activated charcoal in 15 mL of water every 2 hours, up to a maximum of 10 doses. The first 3 doses are mixed with 25 g of sodium sulphate.
- Children are given half the dose.

Vomiting induction

- It is only useful in the first few hours following ingestion of the poison.
- Contraindicated in unconscious people.
- Syrup of ipecac is used at a dose of 30 mL with 250 mL of warm water in adults, or 20 mL with 200 mL of warm water in children aged 5-12 years.
- If 150-200 ml of fluids are given before or after the syrup, the chances of causing vomiting are increased.
- If vomiting does not occur within 20-30 minutes, the dose may be repeated. If vomiting does not occur within 5 minutes of the second dose, a gastric lavage is necessary.

Section III

PROBLEMS ARISING FROM ACCIDENTS

CHAPTER 14
Cardiopulmonary resuscitation

CHAPTER 15
Mountain first aid and emergency procedures

CHAPTER 16
Immobilising and moving the victim

CHAPTER 17
Analgesia and sedation

CHAPTER 18
Helicopter evacuation

CHAPTER 19
Haemorrhage, shock and suspension trauma

CHAPTER 20
Cranioencephalic and vertebral column trauma

CHAPTER 21
Thoracic and abdominal trauma

CHAPTER 22
Musculoskeletal lesions

CHAPTER 23
Soft tissue injury

CAPÍTULO 24
Burns and scalding injuries

CHAPTER 25
Injuries in canyoning and caving

CHAPTER 26
Avalanches

14 CARDIOPULMONARY RESUSCITATION

THE CARDIORESPIRATORY SYSTEM

The basic structure of the human body is the cell; clusters of cells constitute the tissues, and a set of tissues makes up the organs. Organs are part of the apparatus or systems, the whole of which makes up the body.

Cells need to have energy to live. Energy is obtained by burning glucose in the presence of oxygen inside the cells, in small intracellular organs called mitochondria. Without oxygen the cells die.

The intake of oxygen is a function of the respiratory system, and its distribution, of the cardiovascular system.

Respiratory system

The respiratory system is responsible for introducing oxygen into the body. It is located in the chest cavity, protected by the ribs, sternum and vertebrae, and separated from the abdominal cavity by the diaphragm.

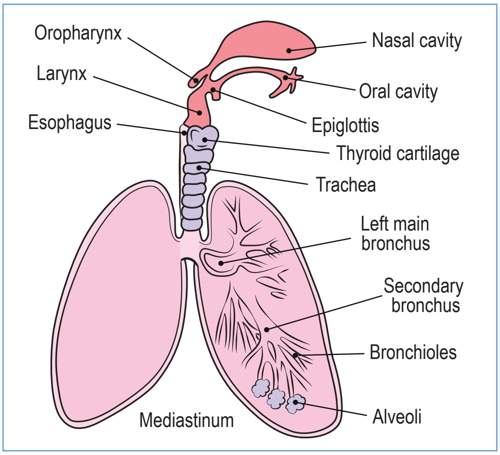


Figure 14.1. Respiratory tract.

It is made up of:

- The airways.
- The lungs.
- The pleura.
- Motor elements.

Airways

Their main function is to carry air from the atmosphere to the lungs. They are made up of:

- The nose.
- The mouth and pharynx.
- The larynx, separated from the digestive Tract by the epiglottis: it is the place where The vocal cords are found.
- The trachea.
- The bronchi.

Lungs

Their basic structure is composed of alveoli, small sacs that swell and deflate with respiratory movements. They are in intimate contact with the blood capillaries and inside them gas exchanges are carried out that allow oxygen to be incorporated into the blood and carbon dioxide to be eliminated.

Pleura

Are thin membranes that wrap around the lungs and the inside of the rib cage to maintain internal pressure. Between the pleura attached to the lungs (visceral pleura) and the pleura attached to the rib cage (parietal pleura) a virtual space is formed that, in the case of pneumothorax, fills with air and may even compress and collapse the lungs. In the case of hemothorax, this virtual space fills with blood and can lead to the same problems.

Motor elements

- Rigid: rib cage, made up of the spine, ribs, and sternum.
- Mobile: muscles (diaphragm, intercostals, etc.).
- Regulators: nerves and respiratory center located in the medulla oblongata.

Dynamics of the respiratory system

The entry and expulsion of gases is done through the respiratory movements that are:

- Inhalation.
- Exhalation.

Inhalation is the process by which air enters the lungs due to the contraction of the diaphragm and intercostal muscles. Their contraction generates a descent of the diaphragm towards the abdominal cavity and an elevation of the ribs. All of this leads to an increase in the intrathoracic volume and the generation of a subatmospheric pressure within the thorax that causes air to enter. Thus it is an active movement that requires muscular work.

Exhalation is the reverse process and causes the expulsion of air. It is a passive movement that is carried out thanks to the elasticity of the moving elements.

The usual breathing rate for healthy adults is between 10 and 25 breaths per minute.

Cardiovascular system

This has the function of distributing oxygen throughout the body.

It is made up of:

- A pump: the heart.
- A system of channels: the blood vessels.
- A carrier fluid: blood.

Heart

It is an empty muscle located in the chest cavity called the myocardium. It makes some contraction (systole) and relaxation (diastole) movements called heartbeats, which cause the blood to move through the blood vessels. The heartbeats can be detected by the transmission they generate in the arteries (pulse). The heart of a healthy adult at rest beats 60-95 times per minute.

Blood vessels

There are basically three types of vessels:

- Vessels leading away the heart: arteries.
- Vessels leading to the heart: veins.
- Gas exchange vessels to the cells: capillaries.

The vessels form two circuits.

- Major circuit: goes from the left ventricle to the right atrium and passes through the entire body. It sends oxygen to the whole body through the arteries.
  - The oxygen circulating through the blood around this circuit crosses the vessel wall and reaches the cells, where it contributes to the combustion of glucose to obtain energy.
  - Carbon dioxide resulting from the reaction of oxygen with glucose passes through the cell and vessel walls and back into the bloodstream to return to the heart, through the veins, via the right atrium.
- Minor circuit: goes from the right ventricle to the left atrium and passes through the lungs.
  - Carbon dioxide circulating in the blood passes through the wall of the pulmonary vessels and alveoli and is expelled.
  - Oxygen travels the reverse way and enters the blood back to the heart through the left atrium.

Blood

The fluid flowing through the blood vessels. There is a liquid part (plasma) and a solid part (cells). Among the cells are the red blood cells, which are the oxygen carriers.

LIFE SUPPORT

Life support is a set of techniques that are applied to a patient in cardiac arrest. These techniques require regular learning, updating and training.

Life support techniques are updated regularly, and the version described in the text corresponds to the American Heart Association's 2015 clinical practice guide.[198-202]

Cardiac arrest is the sudden cessation of heartbeat with the interruption of blood circulation, and therefore of the supply of oxygen to the tissues.

Consciousness is lost 3 to 11 seconds after interruption of cerebral blood flow. Therefore, a semi-conscious injured person is not in cardiac arrest.

A lack of oxygen for 3 to 10 minutes can lead to irreversible brain damage. Cyanosis is usually not seen until the hypoxemia is severe (oxygen saturation<80%).

Pupillary dilation appears 30-60 seconds after the onset of the case and may provide guidance on the effectiveness of resuscitation, but has no value in hypothermia.

Initial survival after cardiac arrest is 30-37%, but only 10-13% are still alive after one year. If the cause of cardiac arrest is trauma, survival is about 2.2%. The outcome is worse when basic CPR techniques are not started within the first 4 minutes, advanced resuscitation techniques are not started within 10 minutes, or resuscitation is longer than 15 minutes. It takes no more than 10-20 seconds to perform an assessment of consciousness, airway and breathing to begin basic CPR if needed.

If the victim has no signs of life (consciousness and effective breathing), it is assumed that he or she is in cardiac arrest.

The main cause of mountain cardiac arrest is ischemic heart disease, usually during hiking or skiing.

Reversible causes of cardiac arrest are:

- Hypoxia.
- Hypovolemia.
- Hyperkaliemia, hypokalemia, hypoglycemia, hypocalcemia, acidosis, and other metabolic disorders.
- Hypothermia.
- Tension pneumothorax.
- Cardiac tamponade.
- Toxic.
- Thrombosis (pulmonary embolism, ischemic heart disease due to coronary thrombosis).

Basic life support

Basic life support consists of keeping the airway free and open, performing good chest compressions, and practicing supportive ventilation without any special equipment or medication at any time. The sequence of action is as follows:

Protect

The first thing to do is to obtain safe access, assessing the environment to detect possible risks that may affect the injured person and the rescuer (avalanche), and taking the appropriate measures to avoid additional risks.

Assessing consciousness

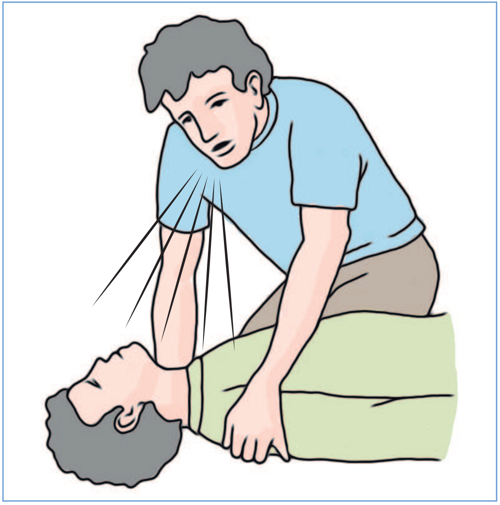


Figure 14.2. Check consciousness

First, shake the victim gently by the shoulders and ask aloud and loudly how they are doing to determine if they are conscious. If the injured person talks and breathes correctly, the airway is open.

If they are conscious, the A-B-C-D-E evaluation is continued.

Keep the airway open by protecting the cervical spine (A)

Clearness of the airways

If the injured person is unconscious, make sure that the airways are clear. In an unconscious patient, because of the loss of muscle tone caused by central nervous system depression, the base of the tongue often obstructs the airways. It may also be blocked by blood, vomiting, secretions, foreign bodies (snow, teeth, etc.), facial injuries or pharyngeal-tracheal injuries.

Initial treatment if the airway is obstructed

In patients in whom no cervical trauma is suspected, head-tilt/chin-lift manoeuvre is recommended: one hand is placed on the forehead and two fingers of the other hand are placed under the jaw, tilting the head slightly and very gently backwards while moving the jaw forward. Fingers should not squeeze the soft tissues inside the jaw. The thumb will gently depress the lower lip. This method is most beneficial if the patient is still breathing.

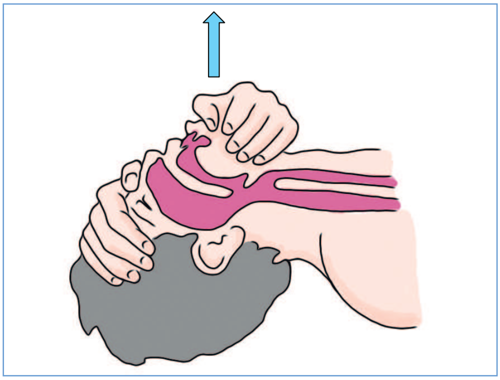


Figure 14.3. Head-tilt/chin-lift manoeuvre.

In patients with a suspected cervical trauma: 2% of patients suffering a physical trauma event have a spinal injury, a possibility that increases in the case of an injury above the collarbone or a score below 8 on the Glasgow scale. The medical history is very informative **(B)**.[203] but injury can only be ruled out after a cervical CT scan, never by a normal neurological examination. Therefore, it is advised to act as though spinal cord injury is suspected, especially for unconscious patients **(A)**.[203]

If spinal cord injury is suspected, an attempt is made to keep the cervical spine in a neutral position on the midline. To do this, the head is held firmly by the sides (mastoid and occipital process), avoiding any traction or sudden movement **(B)**.

In this case, it is preferable to open the airway by lifting the jaw instead of the chin-lift manoeuvre **(B)**. This manoeuvre is performed by placing one hand on each side of the face, with the thumbs on the jaw and the forefingers under the mandibular branches. The indices exert pressure to move the jaw forward while maintaining cervical alignment and immobilisation.

You can also lift the jaw by grasping it with your fingers and pulling it upward.

Since ventilation is a priority **(A)**, if jaw elevation is not effective in opening the airway, the chin-lift manoeuvre should be used carefully, performing hyperextension of the neck only until air is able to enter the lungs.

Oropharyngeal and supraglottic devices may be used: Guedel cannula, laryngeal tube, laryngeal mask, i-gel mask, or Fastrach intubation laryngeal mask.

If a foreign body is suspected, the recommendations described under “Choking” should be followed.

Suctioning of secretions may be necessary.

Cervical spine protection

The cervical spine is initially stabilised manually.

If cervical injury is suspected, this neutral position can be maintained during transport with a vacuum mattress. Routine application of a cervical collar or bilateral sandbags is not usually recommended because the benefits do not outweigh the potential adverse effects (especially endocranial hypertension and airway involvement).[198]

Evaluate if the patient is breathing (B)

To assess breathing, keep the airway open, observe chest movements, listen to possible breath sounds, or feel the breath of the injured person on the rescuer’s cheek. Agonal respiration (<6 breaths per minute) is not considered good enough.

All these manoeuvres are performed within a maximum time of 10 seconds, before deciding if there is no breathing. In practice, the assessment of breathing is usually performed at the same time as the manoeuvres to keep the airway open are practised.

Recovery position

If the victim is breathing but unconscious, they are placed in a safe lateral position, so that the tongue falls forward, leaving the airway open and also allowing mucus, saliva and vomit to escape. To achieve the recovery position, kneel down beside the victim and make sure that both their legs are straight.

The airway is opened by gently tilting the head back and pulling on the jaw. The arm closest to the rescuer is placed at right angles to the victim's body, with the elbow flexed at 90° and the palm of the hand facing upwards. The arm and hand furthest from the lifeguard are resting on the chest of the injured person. The injured person's arm is held with one of the rescuer's hands, while the other holds the far leg at knee level. The leg is pulled upward, keeping the victim's foot in contact with the ground.

Afterwards, a gentle rolling movement towards the rescuer is carried out. The head is tilted back and the victim's hand is placed up below his or her lower cheek to keep the head tilted and to prevent the patient from rolling over onto their face. The correct position of the upper leg is checked, ensuring proper alignment. Finally, breathing is re-evaluated.

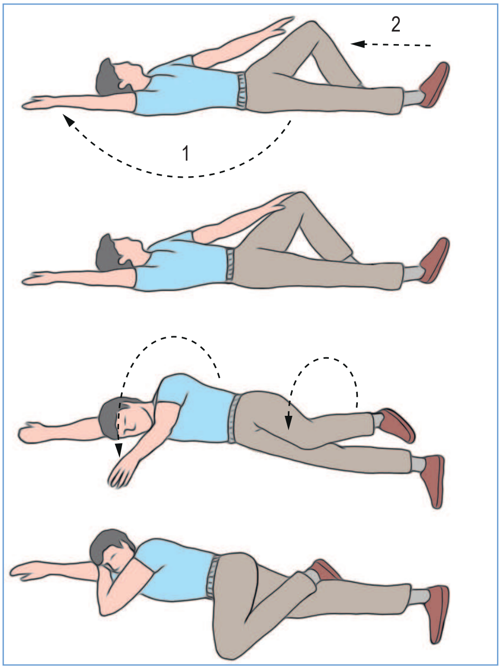


Figure 14.4. Recovery position.

The recovery position must allow good access to the airway, adequate drainage of secretions and the ability to turn the victim face up at any time in an easy and safe manner. This position must not increase the risk of injury to the patient. Regularly check that the patient is still breathing. If placed in the recovery position, make sure to change sides every 30 minutes to avoid nerve compression.

CARDIOPULMONARY RESUSCITATION (CPR)

If the victim is not breathing, call 112 to report a cardiac arrest so that help can arrive with a defibrillator.

Afterwards, cardiopulmonary resuscitation (CPR) manoeuvres can be started.

CPR can be performed by one or two first-aiders.

One first-aider

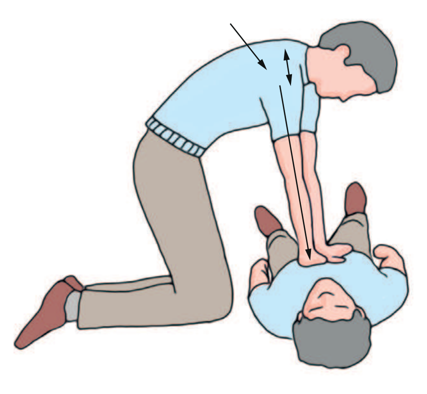


Figure 14.5. Thoracic compressions.

The rescuer places themself next to the patient, who will remain on their back and on a firm surface. The heel of one hand is placed in the middle of the chest and the heel of the other hand is placed on top with the fingers intertwined. The arms, extended with the elbows rigid so that the weight of the body falls perpendicularly onto the desired point. Pressure is exerted to depress the sternum about 5 cm. Do not make sudden movements or separate your hands from the victim's chest.

Thirty chest compressions are performed at a rate of approximately 100-120 compressions per minute (about two compressions per second). Cardiac massage is not able to generate blood flow greater than 30% of cardiac output.

After 30 chest compressions, 2 rescue breaths are given. To do this, the airway is kept open with the chin-lift manoeuvre, pinching the nose with the hand that is on the forehead; the air is inhaled normally and then exhaled into the victim's mouth.

The air insufflation should last 1 second, always observing the thorax elevation. Maintaining the same head inclination and jaw traction, the mouth is removed and the nostrils are opened to facilitate the victim's passive exhalation, checking the descent of the rib cage (2-4 seconds). In these 1.5-2 seconds, about 700-1,000 mL of air is blown in, which is sufficient for adequate ventilation. A higher volume of insufflation increases the risk of gastric insufflation. This maneuver is performed twice **(B)**.

Continue the combination of 30 compressions and 2 breaths until the victim breathes normally, another professional takes care of the situation, or the rescuer is exhausted.

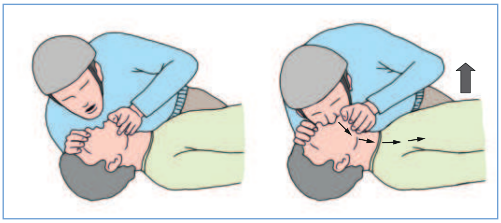


Figure 14.6. Mouth-to-mouth resuscitation.

Two first-aiders

The tasks may be distributed: while one rescuer starts CPR, the other calls for help.

One rescuer can perform compressions while the other one does the ventilations. At the end of each series of 30 compressions, the first-aider in charge of the breathing should be prepared to insufflate as soon as possible, and pauses should be minimised. For this purpose, it may be useful for the ski patrol member performing chest compressions to count aloud: "1-2-3-4-5..." so that the other person is attentive to his or her turn.

Every 2 minutes (or five cycles), to avoid fatigue, the rescuers swap places in less than 5 seconds.

The cardiac massage should only be stopped (less than 5-10 seconds) to intubate, check the pulse or defibrillate.

Once intubated, a rescuer will continue to perform chest compressions at a rate of 100-120 per minute without pauses to ventilate **(B)**, as, during the first few minutes after cardiac arrest, oxygenation of the heart muscle and brain is more compromised by a decrease in blood supply than by a decrease in blood oxygen, which is not yet significant. In the meantime, the other rescuer will ventilate with a bag valve mask (BVM/'Ambu bag') at a rate of 8-10 breaths per minute, without the need to synchronise with compressions.

If oxygen is available, it is administered to achieve SpO_2 of 94-98%.

Continue the combination of 30 compressions and 2 breaths until the victim breathes normally, another practitioner takes control of the situation, or if the rescuer is exhausted.

If aiders do not wish to apply rescue breaths, only chest compressions are performed.

External defibrillator

The majority of cardiorespiratory arrest survivors belong to the group of patients who have suffered ventricular fibrillation or pulseless ventricular tachycardia. The specific treatment for these arrhythmias is defibrillation, which, when performed promptly, can lead to the restoration of an adequate rhythm and prolonged survival. The chances that defibrillation will be effective decrease by 7-10% for every minute that defibrillation is delayed.

Table 14.1. Survival time between cardiac arrest and defibrillation

Time (minutes)	Survival (%)
1	90%
5	50%
7	30%
9-11	10%
>12	2-5%

CPR performed while waiting for the defibrillator prolongs ventricular fibrillation and contributes to the preservation of heart and brain function while the defibrillator arrives, however it is not useful for reversing ventricular fibrillation at a normal rate. With CPR, many patients with ventricular fibrillation have survived without neurological consequences, even if defibrillation was performed within 6-10 minutes of the arrest.

For all these reasons, the use of automatic or semi-automatic defibrillators has become widespread.

They all work by following four simple steps:

- Connect the device.
- Attach the device to the patient.
- Start the rhythm analysis.
- Electric shock if necessary.

The defibrillator indicates these steps itself through voice and text messages.

When the defibrillator arrives, while one rescuer continues to perform chest compressions, the other places the self-adhesive patches, one below the right collarbone and the other above the left lower ribs in the anterior axillary line, just at the position of the tip

Figure 14.7. Basic life support.

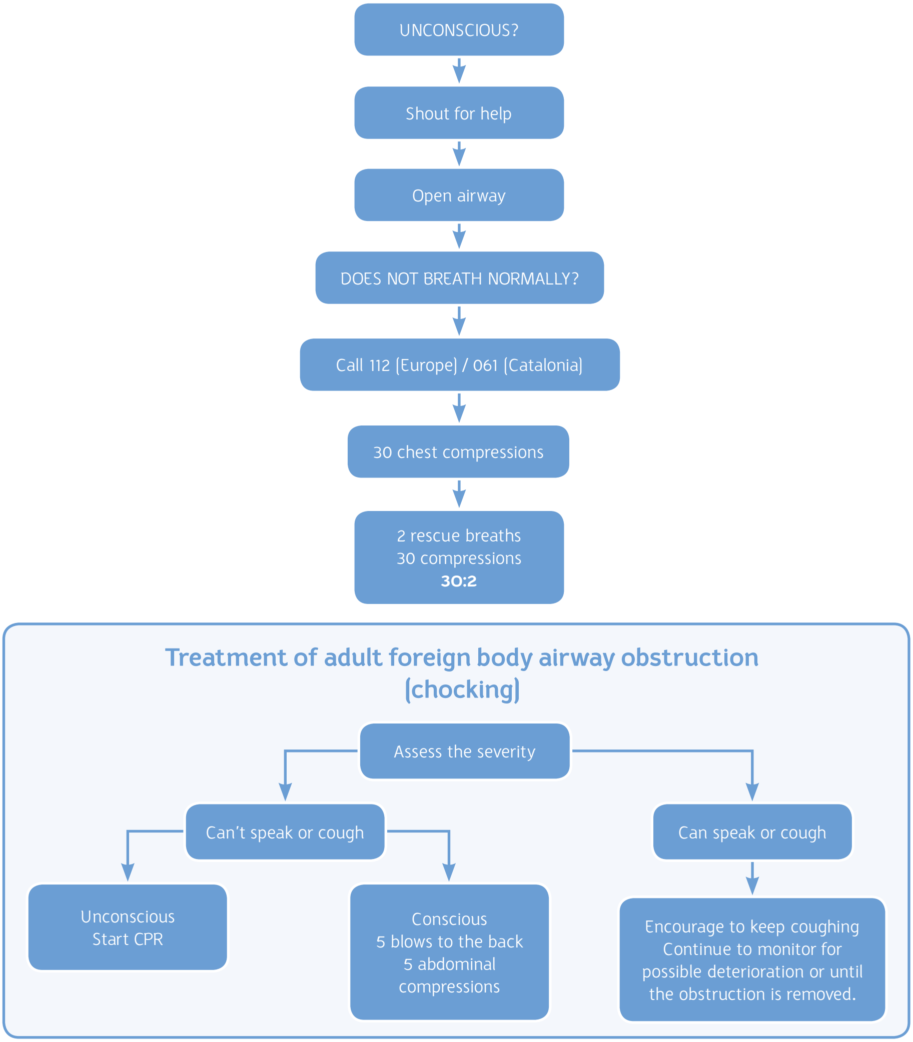
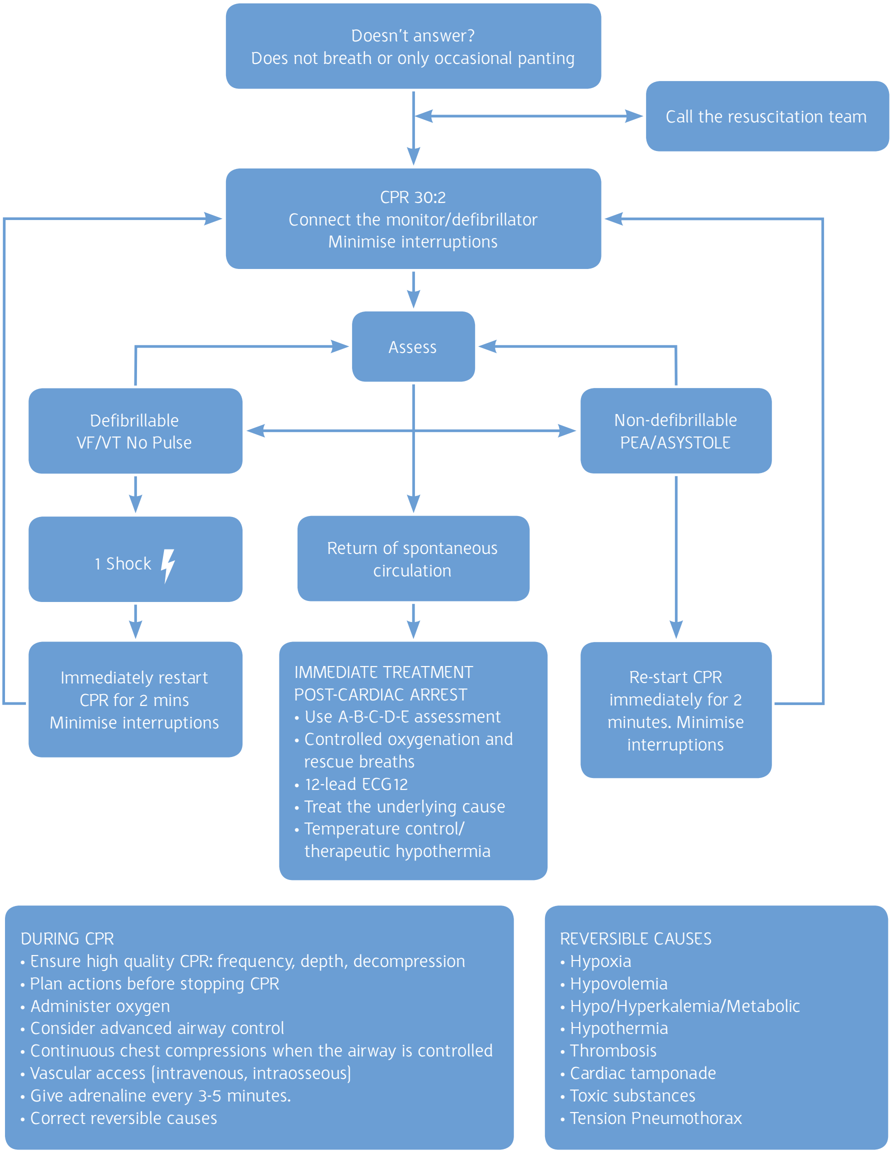

UNCONSCIOUS?
Shout for help
Open airway
DOES NOT BREATH NORMALLY?
Call 112 (Europe) / 061 (Catalonia)
30 chest compressions
2 rescue breaths
30 compressions
30:2
Treatment of adult foreign body airway obstruction (chocking)
Assess the severity
Can't speak or cough
Can speak or cough
Unconscious
Start CPR
Conscious
5 blows to the back
5 abdominal compressions
Encourage to keep coughing
Continue to monitor for possible deterioration or until the obstruction is removed.

Figure 14.8. Advanced life support.


Doesn't answer?
Does not breath or only occasional panting
Call the resuscitation team
CPR 30:2
Connect the monitor/defibrillator
Minimise interruptions
Assess
Defibrillable
VF/VT No Pulse
Non-defibrillable
PEA/ASYSTOLE
1 Shock
Return of spontaneous circulation
Immediately restart CPR for 2 mins Minimise interruptions
IMMEDIATE TREATMENT POST-CARDIAC ARREST
• Use A-B-C-D-E assessment
• Controlled oxygenation and rescue breaths
• 12-lead ECG12
• Treat the underlying cause
• Temperature control/ therapeutic hypothermia
Re-start CPR immediately for 2 minutes. Minimise interruptions
DURING CPR
• Ensure high quality CPR: frequency, depth, decompression
• Plan actions before stopping CPR
• Administer oxygen
• Consider advanced airway control
• Continuous chest compressions when the airway is controlled
• Vascular access (intravenous, intraosseous)
• Give adrenaline every 3-5 minutes.
• Correct reversible causes
REVERSIBLE CAUSES
• Hypoxia
• Hypovolemia
• Hypo/Hyperkalemia/Metabolic
• Hypothermia
• Thrombosis
• Cardiac tamponade
• Toxic substances
• Tension Pneumothorax

of the heart, avoiding the breast in women. If the patient is wet, dry the chest before applying the patches.

Chest compressions should be stopped and the patient should not be touched while the defibrillator analyses the rhythm and when the shock is delivered. Minimize the time that chest compressions are stopped (less than 5 seconds).

Complications

Complications of cardiopulmonary resuscitation include:

- Complete rib and sternum fractures.
- Hemothorax.
- Pneumothorax.
- Hemopericardium.
- Ruptures of liver and /or spleen.

To prevent them, avoid squeezing on the tip of the breastbone, avoid touching the ribs with your fingers, and avoid sharp movements.

Intermediate - advanced life support

Current recommendations for Intermediate - advanced life support outline two major patterns depending on whether the heart rhythm is defibrillable (ventricular fibrillation/pulseless ventricular tachycardia) or non-defibrillable (asystole/pulseless electrical activity).

Shockable rythm

If there is a defibrillable rhythm, a shock is performed with an energy of 150-200 J in biphasic defibrillators (most semiautomatic ones) and CPR is continued for two minutes (5 cycles) without checking the rhythm or pulse. If the defibrillable rhythm goes on, a second shock is performed and two more minutes of CPR (5 cycles) are given. If the defibrillable rhythm persists, a third shock is given and then 1 mg of intravenous adrenaline (10 mL 1:10,000 or 1 mL 1:1,000) and 300 mg of amiodarone are administered while continuing with CPR.

If the rhythm still persists, continue with the two-minute (5-cycle) sequences of CPR followed by a shock. 1 mg of adrenaline is given on alternate defibrillation cycles (every 3-5 minutes).

If the defibrillable rhythm persists, another dose of amiodarone of 150 mg may be administered **(B)**.

Although the 2015 Resuscitation Guidelines recommend the administration of adrenaline, its use is associated with a reduction in long-term survival and a Cochrane review is currently being conducted to determine its role in the treatment of cardiac arrest.[204]

If defibrillation is effective, two more minutes of CPR (5 cycles) are practised before postresuscitation treatment is given.

Non-shockable rythm

If there is a non-defibrillable rhythm, 1 mg of adrenaline is administered and can be repeated in alternate cycles (every 3-5 min).

About 80% of patients recover their heart rhythm on one of the first three defibrillations.

Optimisation of airway control[205]

To facilitate respiratory support during basic CPR, the opening and isolation of the airway should be optimised, as well as artificial ventilation and oxygenation with the available means. An open airway does not benefit the injured person unless they are properly ventilated. Ventilation may be compromised by airway obstruction, but also by alterations in respiratory mechanics or by depression of the central nervous system. Agitation suggests hypoxaemia and hypercapnia stupor.

It is urgent to ensure proper ventilation, intubating if necessary, in patients with agonal breathing (<6 breaths per minute) **(A)**, SpO_2 <90%, GCS <9, systolic TA <90 mmHg or respiratory rate >29 breaths per minute **(B)**.[203]

Pulse oximetry may not be reliable during exposure to intense light or in cases of hypothermia due to vasoconstriction and deviation of the hemoglobin saturation curve to the left, but it may be useful when it is available and the patient is normothermic and protected from intense light. Pulse oximeters are inaccurate for saturation values below 75%.

Table 14.2. Correlation between arterial oxygen saturation and arterial oxygen pressure

PaO_2 (mmHg)	Sp O_2 (%)
100	98.4
80	95
59	90
48	80
40	73
30	60

Plan of action for the airway

The priority is to ventilate, not to intubate.

Assess:

- If the patient is conscious and speaks correctly: the airway is clear.
- If the patient is conscious and you hear stridor: the airway has some degree of obstruction, you must act.
- If the patient is unconscious (e.g. head trauma with Glasgow <9): the tongue obstructs the airway, you must act.

Action:

- Mandibular traction maintaining control of the cervical spine.
- Aspiration of secretions, if possible.
- Removal of foreign bodies only if it can be done easily.
- Placement of Guedel cannula and ventilation with a bag valve mask (BVM). Airway management by Guedel cannula patching and BVM is associated with lower mortality compared to endotracheal intubation or the use of other supraglottic devices.[206-209]
- Assess the use of a supraglottic device other than the Guedel cannula (laryngeal tube, laryngeal mask, i-gel mask, Fastrach) to better isolate the airway from the oesophagus.[210] Comparing the use of supraglotic devices with orotracheal intubation shows no difference in hypoxemia, neurological prognosis and survival.[211, 212] Airway opening success is: laryngeal mask 87.4%, laryngeal tube and Fast Trach 96.5%, cricothyroid puncture 65.8%.[206, 213]
- Oxygen therapy: the air exhaled in mouth-to-mouth ventilation has only 16-18% oxygen. With a BVM, the concentration is that of the ambient air (21%). If connected to an oxygen source with a flow rate greater than 10 L/min, it will increase to 40-60% if the balloon has no oxygen reservoir bag, and 90-100% if it has one. In case of cardiorespiratory arrest, oxygen therapy is started at 15 l/min and then adjusted to achieve SpO_2 94-98%.
- If the doctor considers its need, intubation will be implemented. Orotracheal intubation may be difficult (>15% of intubations failed)[203] and potentially dangerous, and therefore requires experience and continued training (125 initial learning intubations and 2-6 monthly to maintain the ability) **(A)**.[214] If 3 attempts fail to achieve orotracheal intubation, an alternative method should be used **(A)**.
- Intubation through the Fastrach type laryngeal mask requires less learning time, is less traumatic and does not increase intracranial pressure (ICP). After fitting the tube, the correct placement is checked by listening to both hemothoraxes in the axillary line (in the hospital the capnograph is used). The use of the Airtraq laryngoscope is only recommended for highly trained personnel.[215]
- If necessary, a cricothyroid puncture or cricothyroidectomy may be performed.
- If there is no severe maxillofacial injury, a nasogastric tube may be placed to decompress the stomach and reduce the risk of bronchoaspiration.

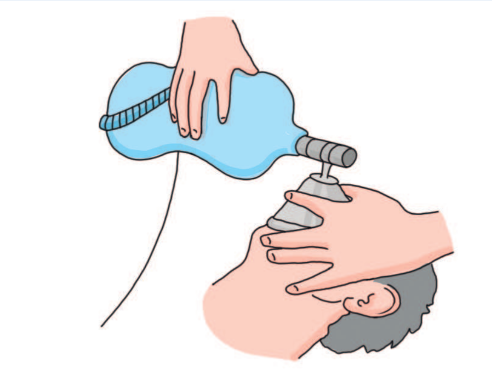


Figure 14.9. Ventilation with a bag valve mask.

Oropharyngeal cannulas

These are tubes that, when introduced into the upper airway through the mouth, serve to maintain the opening of the airway by preventing the base of the tongue from falling against the posterior wall of the pharynx. They also facilitate the aspiration of secretions.

The length of the cannula should be similar to the distance between the oral commissure and the beginning of the auricle.

The approximate sizes are:

- Big adult: 100 mm (Guedel nº 5).
- Medium adult: 90 mm (Guedel nº 4).
- Small adult: 80 mm (Guedel nº 3).

It is placed in the mouth with the concavity towards the palate, it is rotated halfway and turned 180º until it reaches the correct position.

It should not be used on conscious patients, as it may induce agitation and vomiting with consequent bronchoaspiration.

Cannulas may show complications:

- Obstruction of the airway if the tongue is pushed back or the tube is too short.

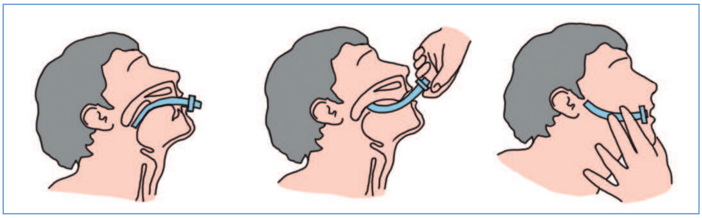


Figure 14.10. Guedel cannula placement

- Spasm of the larynx if it is introduced excessively as the tube is too long.
- Nausea, vomiting, and bronchoaspiration in conscious patients.

Orotracheal intubation, laryngeal mask, i-gel supraglottic airway, Fastrach, laryngeal tube, cricothyroid puncture and cricothyroidotomy (see Chapter 28)

Suction systems

Suction systems with a vacuum source, a reservoir flask and suction probe connection system are very useful.

The suction system must be able to achieve a maximum pressure in a closed tube of 300 mmHg and a maximum flow rate in an open tube of 30 litres per minute.

Aspiration is performed by means of sterile probes that are connected to the aspirator and inserted through the mouth, nose or opening in the airway.

The sterile probes are inserted without aspiration until they are placed in the desired position.

In the case of tracheal suctioning, to avoid hypoxia, aspiration is performed for periods of less than 5 seconds, with oxygen at high concentrations being provided before and after each suctioning for at least one minute.

A suction system can be improvised with a suction probe and a large syringe (100-200 cc).

Respirators

Generally, medical helicopters and ambulances carry a respirator that only has volumetric ventilation modes.

It is difficult to generalise and propose universal initial ventilation parameters for all patients. The presence or absence of pulmonary and/or neurological pathology can be conditioning factors that cause us to modify the way we program the respirator. In general, the initial parameters with which we can program the respirator and modify it according to the clinical response of the patient are:

- Respiratory rate (RR): 14-20 breaths per minute.
- Current volume (CV): 8-10 mL/kg.
- Minute volume (MV): RR x CV.
- Oxygen-inspired fraction (FiO_2): 1 or the fraction needed to maintain SpO_2>90% or 95% in the case of traumatic brain injury (TBI).
- Inhalation:exhalation ratio (I:E): 1:2 or 1:3.
- Final positive end-expiratory pressure (PEEP): prevents expiratory collapse of alveolar units by improving pulmonary mechanics and oxygenation. Generally, PEEP levels of about 5 cm H_2O are used. Although elevated PEEP levels can improve oxygenation, they can also make venous return difficult and aggravate endocranial hypertension in patients with TBI. In addition, they can aggravate an air leak.

Cessation of cardiopulmonary resuscitation

CPR is usually continued until specialised help arrives, the victim shows signs of recovery (spontaneous ventilation, palpable pulses, or regaining consciousness), or the rescuer is exhausted.

In the wilderness, there are situations in which cardiorespiratory resuscitation manoeuvres are not initiated or completed in patients in the absence of vital signs (any of these are present):[216, 217]

- Unacceptable risk to the rescuer.
- Decapitation, trunk separated from the body, incineration or decomposition of the whole body.
- Whole body frostbite with non-compressible chest.

- Avalanche victim in asystole with airway obstruction and burial time >35 minutes.

Completion of cardio-respiratory resuscitation (CPR) manoeuvres in a person with non-present cardiorespiratory arrest (all of them are present):

- No return of spontaneous circulation for 20 minutes of CPR; AND
- No discharge recommendation by the AED at any time or ECG showing only asystole; AND
- No hypothermia or any other circumstance that would suggest prolonging CPR.

Choking

In order to oxygenate the body's cells, it is necessary for air to enter the lungs. When oxygen does not reach the brain for 3-11 seconds, consciousness is lost and cardiorespiratory arrest follows. This is why it is urgent to clear the airways.

Choking often happens while the patient is eating.

If the airway obstruction is partial, the victim coughs, is distressed, and usually holds their hand to their neck. You may be able to expel the foreign body with the cough reflex.

If the obstruction is complete, the patient cannot speak, cough or breathe and loses consciousness in a short time.

Attitude in the face of choking:

- If the victim is breathing, encourage him/her to keep coughing, without doing anything else.
- If the victim shows signs of exhaustion or stops coughing or breathing, they should be kept in the same position, any foreign objects removed from the mouth, as well as dental prostheses, and given five vigorous slaps on the back.
- If slapping the back is not effective, abdominal compressions are performed. To do this, the arms are placed behind the patient and intertwined around the waist.
- Find the navel with the fingers of one hand, and place the fist of the other hand above the fingers pointing to the navel, with the thumb toward the patient. Afterwards, the fist is covered with the hand pointing to the navel. Once the hands are between the navel and the lower edge of the chest, five successive compressions are done.

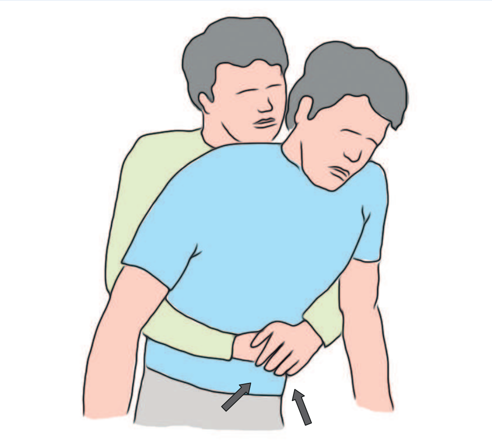


Figure 14.11. Heimlich manoeuvre.

- If the patient is unconscious and the airways have not been cleared with the manoeuvre explained, abdominal compressions may also be attempted with the patient on his or her back.
- If this procedure fails, digital extraction may be attempted. Open their mouth and hold their tongue and jaw between your fingers; place your second finger at the base of their tongue and try to remove the obstruction. If you can't get to it, don't try.
- If this is not effective, alternate five pats on the back with five compressions. If the victim is not breathing, two breaths are given and the series of five pats on the back and five compressions are continued, maintaining rescue breaths at the end of each series.

15

MOUNTAIN FIRST AID AND EMERGENCY PROCEDURES

OVERVIEW

The primary objective in the event of an accident is to treat life-threatening injuries. The main causes of death are:[218]

- In the first few seconds to minutes: apnoea due to severe brain, brain stem or spinal cord injury; heart injury, rupture of the aorta and great vessels.
- Within minutes to several hours: hemo-pneumothorax, cardiac tamponade, severe bleeding (ruptured spleen or liver, complete pelvic fracture or multiple lesions with severe bleeding), subdural or epidural hematoma.
- In the third stage the cause of death is sepsis and multi-organ failure.

Classification of injuries in the mountains[219, 220]

Table 15.1. Classification of injuries in the mountains

Type of care		
Lesion		
Medical problem		
Location *(Orchard Sports Injury Classification System - OSICS)*		
Main group	Category	OSICS
Head and neck	Head/face	H
	Neck/cervical spine	N
Upper limbs	Shoulder/clavicle	S
	Humerus	U
	Elbow	E
	Forearm	R
	Wrist	W
	Hand/fingers/thumb	P
Trunk	Chest (sternum/ribs)	C
	Thoracic spine	D
	Abdomen	O
	Lumbar spine	B
	Pelvis/buttock	L

Table 15.1. (Cont.) Classification of injuries in the mountains

Type of care		
Lower limbs	Hip/groin	G
	Thigh	T
	Knee	K
	Lower leg	Q
	Ankle	A
	Foot/toes	F
Unspecified		X
Severity *(UIAA MedCom Score)*		
0	No injury or illness.	
1	Mild injury or ilness. No medical intervention necessary, self-treatment (abrasion, mild strain, contusion).	
2	Moderate injury or illness. Needs to see a doctor in a few days, needs to leave work, complete non-displaced fractures, meniscopathy).	
3	Serious injury or illness. You need urgent medical evaluation and/or hospitalisation. (Complete minor fractures, dislocations, spinal injuries, TBI).	
4	Life-threatening injury. You need a mobile ICU or a doctor experienced in critical care. Polytrauma or coronary syndrome that was survived.	
5	Life-threatening injury. You need a mobile ICU or a doctor with critical patient experience. Polytrauma or coronary syndrome that was NOT survived.	
6	Death immediately or on arrival.	
Difficulty of the rescue		
I	Technically easy but out of the ordinary accidents, no objective risks. Attention in situ (street, bathroom, etc.).	
II	Few objective risks, easily quantifiable. Falls are not dangerous.	
III	Significant objective risks, difficult to quantify. Falls are dangerous.	
IV	Extremely risky. Falls are deadly.	

MOUNTAIN FIRST AID

Generally, mountain accident victims suffer from polytrauma. A polytraumatised person is one who is injured by a high-energy traumatism that presents at least two serious traumatic injuries, with repercussions for one or several vital functions.

There are a few elements that must be taken into account when assessing the victim's condition:

- Different injuries can interfere with each other and can therefore be underestimated:
  - Injuries that are not dangerous in isolation but are dangerous in addition (e.g. the addition of hematomas can result in significant blood loss and shock from blood loss).
  - One injury may mask another (for example, a spinal cord injury may suppress abdominal pain that would suggest serious injury to an abdominal viscera: spleen, liver or kidney).
  - Self-injury can occur when there is a skull injury and a chest injury (injury to the chest can decrease the amount of

oxygen reaching the brain, aggravating a brain injury, and respiratory depression caused by brain injury can worsen respiratory failure secondary to chest injury).

- At any time the cardiocirculatory system can fail.
- Other aggravating factors are generally associated:
  - Hypothermia; in a traumatic event, a core temperature below 36 °C is already considered aggravating.
  - Altitude: 2,500 m and above can already be an aggravating factor.
  - Pain: causes the injured person to move, displacing a complete fracture, causing a fat embolism and participating in the state of shock.
  - Clotting disorders.
  - Metabolic disorders (metabolic acidosis).
  - Fatigue and stress.
  - Time factor: delay in attending and evacuation, weather and access conditions.

The initial clinical assessment of polytrauma in mountain areas is carried out in two phases **(A)**:[203]

- **Primary assessment**
  - Assess whether the patient is conscious or unconscious.
  - Rule out massive, life-threatening bleeding.
  - **A** (Airway): clear airway with cervical spine stabilisation.
  - **B** (Breathing): proper breathing and ventilation (rule out serious chest injuries that immediately compromise ventilation: massive hemothorax, tension pneumothorax, cardiac tamponade, chest instability with severe pulmonary contusion).
  - **C** (Circulation): circulation and control of bleeding (rule out heavy bleeding: hemothorax, abdominal bleeding, complete fracture of pelvis or long bones, heavy external bleeding and sum of multiple hematomas).
  - **D** (Disability): neurological status (Glasgow or VNDL scale and pupils, hypoglycemia).
  - **E** (Exposition): exposure / environmental control. Protect from hypothermia and check the areas covered by clothing (undress if temperature permits).
- **Secondary assessment of injuries to rule out apparent injuries or pain**
  - Ask about allergies, drugs, pathological history, mechanism of the accident and last food intake.
  - Head.
  - Neck.
  - Thorax.
  - Abdomen.
  - Limbs.
  - Back.
- **Reassess**

After this assessment, the injured person is stabilised in order to be able to be taken to a hospital under normal conditions. For this purpose, we carry out:

  - Emergency prehospital treatment that cannot be delayed without endangering the life of the injured person.
  - Analgesia and sedation if necessary.
  - Transfer to the hospital.

Although, in urban areas, there is controversy about the benefit of pre-hospital care ("stay and play") versus rapid transfer to hospital ("scoop and run"), with a large number of publications supporting the second type of approach; in wilderness, transfer to hospital can be slow, so pre-hospital care plays an important role in the treatment of the injured person.

EMERGENCY PROCEDURES

The objectives are:

- Treat life-threatening injuries.
- Minimise complications.
- Pain management.

The recommended sequence to follow in the event of an accident is as follows:

Situation awareness: Protect, Alert, Save (PAS)

Be aware of the situation: observe the situation and environment, interpret and understand what is happening and what may happen, to make the appropriate decisions and act accordingly.

- Protect: control any danger that may exist for the injured person and the rescue team members (collision with other skiers, avalanche, etc.), and take appropriate measures to avoid additional risks (signpost the accident, use gloves to perform the examination of the injured person, etc.). In the event of danger, safety takes precedence over everything else.

- Alert: Call for help, if possible, by dialling 112 on your mobile phone. If there is no coverage for mobile or radio alerts, two or three messengers should be sent with written information.
- Save: according to the following protocol.

Primary assessment

- It is important to carry out the sequence of actions in an orderly manner, to not move on to a new valuation level without having ensured control of the previous level.
- Continuous re-evaluation of the patient's condition is also necessary.
- Assess reactivity and awareness: stimulate the injured person by gently touching the shoulders and asking the patient about their condition and what has happened, always with cervical stabilisation. If the injured person is able to speak and breathe normally, their airway may not be immediately compromised, although it is prudent to periodically check for airway patency. If the person is conscious: introduce yourself, ask them what has happened and reassure them (psychoanalgesia). If they tell you in detail what happened, their neurological status is likely to be intact.
- Rule out massive, life-threatening bleeding. If there is any, place a tourniquet 5-7 cm above the wound and note down the time **(B)**.[203 221]

(A) (Airway): Assess whether the airway is open, while simultaneously stabilising the cervical spine

Openness of the airway

In an unconscious patient, because of the loss of muscle tone caused by central nervous system depression, the base of the tongue often obstructs the airway. It may also be blocked by blood, vomiting, secretions, foreign bodies (snow, teeth, etc.), facial injuries or pharyngeal-tracheal injuries.

We may consider the airway is open if the patient is conscious and speaks and breathes normally. Any signs of respiratory failure, as well as the absence of effective breathing movements or apnoea, may indicate an airway obstruction.

In a trauma patient, the jaw lift is preferable to chin-lift manoeuvre **(B)** for opening the airway. This manoeuvre is performed by placing one hand on each side of the face, with the thumbs on the jaw and the forefingers under the mandibular branches. The index fingers exert pressure to move the jaw forward while maintaining cervical alignment and immobilisation.

You can also lift the jaw by grasping it with your fingers and pulling it upward.

Since ventilation is a priority **(A)**, if elevation of the jaw is not effective in opening the airway, the carefully use the chin-lift manoeuvre, performing the hyperextension of the neck just enough for air to enter the lungs.

Aspiration of secretions may be necessary.

If a foreign body is suspected, the recommendations described under "Choking" (see Chapter 14) should be followed.

Oropharyngeal devices may be used to protect the airway: Guedel airway, laryngeal tube, laryngeal mask, i-gel mask or Fastrach laryngeal mask.

Stabilisation of the cervical spine

Spinal injury is found in 2% of trauma patients, a possibility that increases in case of injury above the clavicle or Glasgow <8. The medical history is very orientative **(B)**[203], but an injury can only

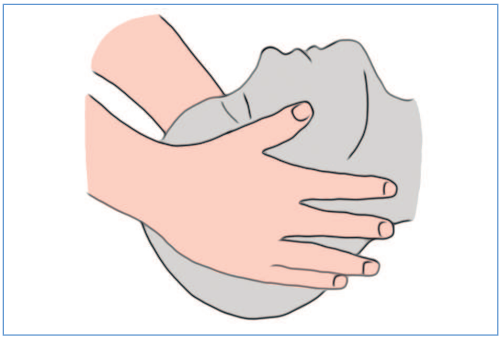


Figure 15.1. Cervical manual control.

ruled out after a cervical CT scan, never with a normal neurological examination. Therefore, it is advised to act as if spinal cord injury is suspected, especially in unconscious patients **(A)**.[203]

Attempts are made to keep the cervical spine in a neutral position on the midline. To do this, the head is held firmly on the sides (mastoid and occipital process), avoiding any traction or sudden movement. If a cervical injury is suspected, this neutral position can be maintained during transport with a vacuum mattress. Routinely applying a cervical collar or bilateral sandbags to the cervical spine is not usually recommended because the benefits do not outweigh the potential adverse effects (especially endocranial hypertension and airway involvement) **(B)**.[198]

(B) (Breathing): Assess if breathing and ventilation are correct

Are they breathing?

An open airway does not have to be associated with effective breathing. To assess whether the patient is breathing, it is necessary to keep the airway open, observe the movements of the thorax, listen to possible breathing sounds or feel the breath of the injured person on the cheek of the rescuer (this must be done simultaneously while performing the airway opening manoeuvre. Agonal respiration (<6 breaths per minute) is not considered good enough.

These actions are evaluated for a maximum of 10 seconds before deciding whether there is no breathing. If the person is unconscious and not breathing, it is assumed that there is a cardiorespiratory arrest and life support practices are initiated.

Are they breathing correctly?

Examination of the thorax and respiration **(A)**.[203]

Determine breathing rate (normal: 10-25 rpm) **(B)**.[222, 203] RR >27 or <10 breaths per minute, suggests a severe thoracic injury[223].

Listen to the lungs, looking for unilateral decreased or abolished breath sounds **(B)**.[203]

Inspect the neck in search of jugular engorgement or tracheal deviation.

Observe chest movements (asymmetry, deformity, paradoxical breathing?) **(C)**.[203]

Palpation (pain, crackling, subcutaneous emphysema, instability?) **(C)**.[203]

Percussion of the thorax (hyperresonance?) **(C)**.[203]

Thorax auscultation (no breathing sounds?) **(C)**.[203]

If a pulse oximeter is available, determine the SpO_2 **(C)**.[203]

Look for severe neurologic injury (ventilation may be secondarily affected by these lesions).

- Tension pneumothorax is a life threatening emergency and requires urgent drainage. It occurs when air enters the pleural space from a lung injury or a penetrating chest wound, trapping it in the pleural space and progressively collapsing the lung. Suspected by decreased or abolished breath sounds on the affected side **(B)**,[203] dyspnea, chest pain, tachypnea, jugular engorgement, hypotension, tachycardia, subcutaneous emphysema in the thoracic or cervical region, tympanitic abdomen on the percussion of the thoracic cavity, contralateral tracheal deviation, shock, or suction in a thoracic wound.
- Open pneumothorax will be suspected in the presence of an open chest wound with dyspnea.
- Unstable chest with pulmonary contusion is suspected when observing a paradoxical movement of the rib cage when breathing (the chest sinks when breathing in air and swells when expelling it), bone crackling, pain, cyanosis, dyspnoea, or shock. Chest instability presupposes an underlying pulmonary contusion.
- Massive hemothorax, a condition usually associated with pneumothorax.

Other less severe thoracic injuries will be identified and treated in the secondary assessment: respiratory failure due to complete rib fractures or central nervous system depression, pneumothorax or simple hemothorax.

Initial treatment

- Oxygen administration at 15 L/min to stabilise and then the necessary to maintain SpO_2 94-98%.

- If tension pneumothorax or massive hemothorax is suspected: perform emergency drainage **(A)**.[203] In a prehospital setting, the insertion of a 14-16 G angiocatheter is recommended **(B)**[203] with a Heimlich valve in the second intercostal space at midclavicular line level (according to the *Advanced Life Support Manual for the polytraumatised* by the SEMICYUC - Spanish Society of Critical Intensive Care Medicine and Coronary Units).
- If an open pneumothorax is suspected: Open thoracic wounds should be immediately covered with a non-occlusive dressing to prevent development of a tension pneumothorax. If there is an open wound with a diameter of 2/3 of the trachea, air is more likely to enter through the wound than through the trachea. The wound can be covered with Vaseline gauzes attached to the skin with adhesive tape at three points, always leaving one point free, so that it acts like a valve. They should be 5-7 cm above the wound. The air will come out during the exhalation and will not enter during inhalation. If Vaseline gauze is not available, cover the wound with sterile gauze and cover that with a thin plastic square (plastic gauze container or plastic bag). Seals with a built-in valve are available to treat open chest wounds (Chest Seal®).
- If thoracic instability is suspected, analgesia may be administered and a stabilisation may be sought. Sometimes the injured person improves by leaning on the injured side to achieve some stabilisation during the transfer. If necessary, the unstable wall can be temporarily restrained with a firmly attached bandage to prevent pain and paradoxical movement, thus improving ventilation.

C (Circulation): Circulation and control of bleeding

Is the heart pumping correctly?

Aside from cardiac arrest, there may be a cardiac tamponade.

Cardiac tamponade is a compression of the heart by the accumulation of blood or fluid in the space between the myocardium and the pericardium, preventing the complete expansion of the heart's chambers, which therefore cannot fill sufficiently or pump blood. Signs that suggest cardiac tamponade include tachycardia, muffled heart sounds, jugular engorgement, and hypotension that does not improve with fluids. There may also appear to be anxiety, chest pain that improves with sitting and leaning forward, shortness of breath, dizziness, pale skin, palpitations, paradoxical pulse (systolic blood pressure may drop more than 10 mmHg when the victim inhales deeply), rapid shallow breathing, weak or absent pulse.

If a pericardial tamponade is suspected, immediate pericardiocentesis should be performed **(B)**,[203] a technique that is difficult to put safely into practice in the wilderness.

Is a haemorrhagic shock suspected?

Haemorrhagic shock is the leading cause of preventable death following an accident. For its early detection, it is useful to assess the state of consciousness, heart rate (normal: 50-95 bpm), skin colour and capillary filling (normal <2 sec).

Tachycardia is an early sign of shock. The heart rate is determined through palpating the carotid pulse by placing two fingers on the larynx (Adam's apple) and then sliding them into the depression between the larynx and the lateral neck muscles so that the fingertips are above the carotid artery. The palpation should be done gently.

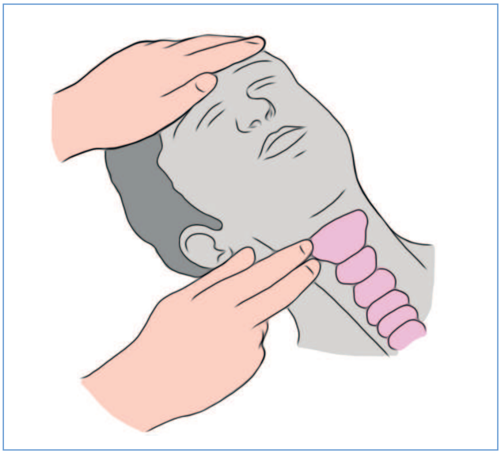


Figure 15.2. Carotid pulse.

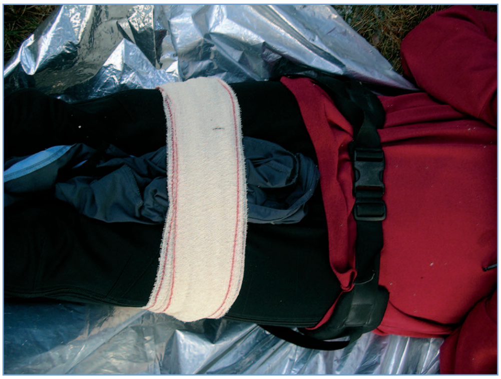


Figure 15.3. Pelvic closure using backpack strap.

Large haemorrhages that can cause hypovolemic shock are caused by: hemothorax, abdominal or retroperitoneal haemorrhage, complete fracture of the pelvis (gentle palpation to avoid aggravating a possible haemorrhage) or long bones and large external haemorrhage.

Initial treatment

Visible bleeding is inhibited by pressure, if very heavy and life threatening, place a tourniquet 5-7 cm above the wound. **(B)**[203, 221] In a first assessment, bleeding control prevails over antiseptic measures.

Bleeding associated with complete pelvic fractures can occur directly from the completely fractured bone, from the pre-sacral venous plexus, or from the iliac vessels. If the cause of shock is suspected to be an unstable complete fracture of the pelvis (fall from height with pelvic pain), stabilise it **(B)**,[203] by reducing the pelvic volume to try to minimise bleeding (e.g. through a pelvic sling).[224] The use of pelvic slings is effective in restoring normal bone anatomy and may reduce bleeding volume, but may also cause local tissue damage. The results of studies on the benefit of their use are heterogeneous, and more studies are needed to determine their efficacy in reducing mortality or bleeding in complete unstable pelvic fractures.[225]

If a complete long bone fracture is suspected, immobilise it **(B)**.[203]

The pulse correlates roughly[226] with the systolic blood pressure as follows:

- Existence of carotid pulse: systolic blood pressure 50-60 mmHg.
- Existence of femoral pulse: systolic blood pressure 60-70 mmHg.[4]
- Existence of radial pulse: systolic blood pressure 70-80 mmHg.

D (Disability)

Neurological assessment (D) using the Glasgow or AVPU scale (an acronym from "Alert, Voice, Pain, Unresponsive). Assessment of pupils (size and photomotor reflex), signs of neurological focus and spinal cord injury.

Signs and symptoms of intracranial hypertension: pupillary asymmetry >1mm ( ), an absence of photomotor reflex (CP+3.6), vomiting and neurological focus.

Table 15.2. Correlation between the Glasgow scale and the AVPU scale[227]

AVPU Scale	Glasgow Scale
Alertness	14 - 15
Verbal response	9 – 14
Pain response	4 – 10
No response	3 – 5

Assess motor or sensory deficits.

Consider hypoglycaemia, alcohol and toxins as non-traumatic causes of impaired consciousness.

During neurological reassessment some criteria for worsening are:

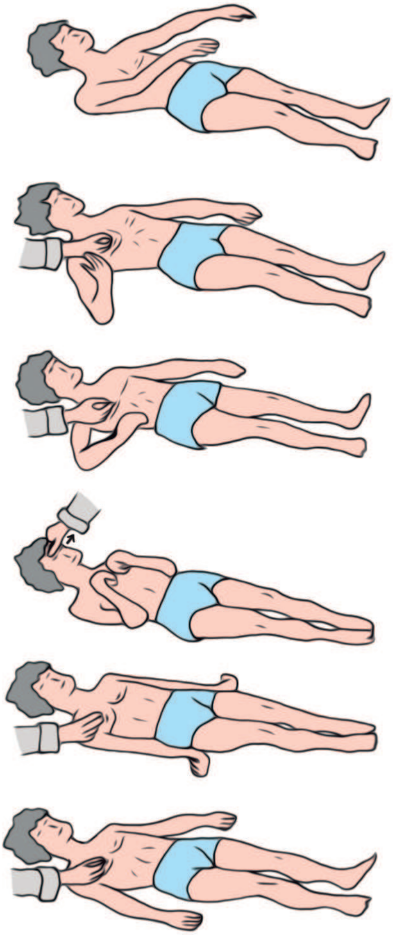
- Sudden drop in consciousness.
- Decrease >2 points on the Glasgow scale.
- Repeated or prolonged convulsions.

Initial treatment: oxygen therapy at 15 L/min to stabilise and then whatever is necessary to maintain SpO_2 98%. Saline perfusion if necessary, to maintain systolic blood pressure of at least 100 mmHg **(B)**.[203]

E (Exposure): Exposure / environmental control. Protect from hypothermia and check the areas covered by clothing for pain or apparent injury (undress if temperature permits)

- Reassess **A, B, C, D and E:** they should be re-evaluated periodically, and especially af-

Glasgow scale:	
Eye opening	
Keeps eyes open	
Never	1
Only to painful stimuli	2
To verbal stimulus	3
Spontaneously	4
Verbal response	
No answer	1
Incomprehensible sounds	2
Inarticulate speech, uses inappropriate words	3
Confused language, disoriented	4
Speaking and oriented	5
Motor response	
No answer	1
Extensor posturing. Decerebrate response	2
Flexor posturing. Decorticate response	3
Flexion-withdrawal from pain	4
Localises pain	5
Voluntary response	6



Total score:
3-15 (considered severe if less than 9 for at least 6 hours after neurological impairment).

Figure 15.4. Glasgow scale.

ter any therapeutic action or relocation to ensure that things remain stable, and so proceed to the secondary assessment.

Secondary assessment

Once the primary evaluation (A, B, C, D and E) has been completed and reevaluated, the secondary evaluation is started.

The main objective is to rule out injuries that may jeopardise the immediate vital prognosis during transport (head trauma without initial focus, simple pneumothorax, internal injuries that have produced shock, limb trauma, cervical spine injury, etc.) and injuries that may have consuences or produce pain. Do this by scanning from head to toe, looking for pain or apparent injuries.

If possible, make a brief anamnesis: allergies, medications, pathological history, pregnancy, last food intake, mechanism of injury, etc.

Cranium

- Cranial vault: inspect the head to rule out external injuries. Palpation to rule out palpable complete fractures.
- Base of the skull: suspect a complete fracture if blood is coming out of the ear or nose, or if there is a bruise behind the ear

or around the eye, even if no deformity or instability of the skull bones can be observed.
- Suspect endocranial hypertension in the presence of vomiting, pupillary asymmetry >1 mm (OR + 9), absence of photomotor reflex (OR + 3.6) and neurological focus.

Neck and cervical spine

- Inspect the neck, looking at the position of the trachea. Tension pneumothorax should be suspected if it has deviated in a thoracic trauma patient. To assess whether the position of the trachea is normal, place two fingers on the midline at the base of the neck, in the cavity above the breastbone, and gently press on the trachea, which should be located in the middle.
- If the jugular veins are distended, pneumothorax or cardiac tamponade should be suspected. If they are collapsed, the hypovolemic shock must be suspected.
- The existence of subcutaneous cervical emphysema suggests pneumothorax or tracheal rupture.
- Assess the presence of lacerations and bruises.
- Explore the back of the neck for crackling or pain, palpate the cervical vertebrae for complete fracture.
- Always suspect injury, especially if there is a trauma above the collarbone, or if there is pain or unconsciousness **(A)**.[203]
- Assess motor and/or sensory deficits.

Suspect a spinal injury when:
- The victim is over 65 years of age.
- It is a bicycle or motor vehicle accident.
- A fall has occurred from higher than standing height.
- There is tingling in the extremities.
- There is neck or back pain or tenderness.
- There is a weakness or tenderness disorder of the torso or upper extremities.
- The victim shows a low level of consciousness or signs of intoxication.
- The victim has other painful injuries.
- It is a child over 2 years old with a Glasgow scale <14.

Thorax

- Assess respiratory rate (normal: 10-25 breaths per minute) and feelings of shortness of breath.
- Inspection, palpation, percussion and auscultation to assess signs of trauma: pain and apparent injuries.
- Severe chest lesions will have been identified and treated in the primary assessment: look for tension pneumothorax, massive hemothorax, open pneumothorax, unstable thorax with pulmonary contusion and cardiac tamponade.
- Other less serious thoracic injuries are identified and treated in the secondary assessment: respiratory failure due to complete rib fractures or central nervous system depression, pneumothorax or simple hemothorax.
- In case of complete rib or sternal fractures, cardiac contusion should be assessed and ruled out.

Abdomen

- It should normally be soft. If there is abdominal guarding, suspect a visceral tear. Remember that certain spinal injuries can inhibit the abdominal wall muscles, and there can be visceral ruptures without abdominal guarding.
- An unstable fracture of the pelvis may result in haemorrhagic shock. Bilateral pelvic compression is painful when there is a complete fracture. Do not attempt to move the pelvis during the examination, as this may trigger retroperitoneal bleeding.

Limbs: lower and upper extremities

- Ask the injured person to move their fingers and toes and to squeeze your hands.
- Check for sensitivity to rubbing or pricking.
- Inspect for wounds, complete fractures and dislocations.
- Clean open complete fractures, cover with sterile dressings and immobilise them **(B)**.[203]
- Immobilise any remaining dislocations and complete fractures starting with those of the femur and pelvis **(B)**.[203]

- Clean and disinfect soft tissue lesions.
- Before and after immobilisation, check for nervous system vascular compromise.

SUMMARY

- Protect.
- Alert (112).
- Save.

Primary assessment

- Reactivity: Is the patient conscious or unconscious?
- Check for massive life threatening external haemorrhage → Direct compression? or apply tourniquet 5-7 cm above the lesion and write down the time of application.

A: Airway patency with manual stabilisation of the cervical spine: See if the airway is functioning by simultaneously balancing the cervical spine

- If the person speaks, the airway is open.
- If it is not open, release → jaw lift (supraglottic device if available).
- No routine use of cervical collar (if used: avoid compressing the airway and venous return).

B: Respiration and ventilation

- Is there breathing or not? If not → start life support.
- How is the patient breathing: calculate RR: if <10 or >25 breaths per minute, there is a possible respiratory problem. Chest palpation: identify tension pneumothorax (pain and choking and unilateral auscultatory silence), unstable thorax and penetrating wound → drain tension pneumothorax, plug penetrating wound with a non-occlusive valve-type dressing. Oxygen (if available) at maximum concentration (if there is a pulse oximeter: adjust to maintain SpO_2 94-98%).

C: Circulation with haemorrhage control

- Calculate HR; if >120 bpm → possible major bleeding →.
  - visible heavy bleeding has not subsided → check compression or tourniquet.
  - complete pelvic fracture → palpate carefully and close pelvis.
  - complete fracture of the femur or long bones → carefully palpate and immobilise.
  - abdominal viscera injury → palpate carefully.
  - Thoracic haemorrhage → palpate carefully (you will have RR >25 breaths per minute).

D: Neurological assessment

- Awareness assessment: AVPU (or Glasgow).
- Palpate the spinal column.

E: Exposure and control of the environment: exploring the areas covered by clothing (undressing if temperature permits), preventing hypothermia

Secondary assessment

- Head.
- Neck and spine.
- Thorax.
- Abdomen.
- Limbs.

16

IMMOBILISING AND MOVING THE VICTIM

MOVEMENT METHODS

Moving the injured person should prevent complications and improve their condition, not worsen existing injuries.

Basic principles

- Material goes to the person, not the person to the material (as far as possible).
- The material must be adapted to the anatomy and not the other way around.
- Minimise the number of movements.
- Be pragmatic: in impossible or dangerous situations, carry out an initial immobilisation as quickly and effectively as possible and then, in a more comfortable and safer area, achieve a more optimised stabilisation and immobilisation.
- Remember that many times, the only thing that can be offered to the injured party is good immobilisation and transfer.

Movements can be emergency or non-emergency.[228-230]

Emergency moves

Emergency moves prioritise speed over the quality of the immobilisation and are used in the face of a risk to the injured person or the rescue party. The Rautek manoeuvre and simple dragging are described.

In case of a suspected cervical injury, it is recommended to perform and maintain a neutral alignment of the spine by means of gentle or moderate traction during the evacuation, except when there is resistance, increased pain, or the onset or worsening of a neurological deficit when attempting traction **(B)**.

Rautek manoeuvre

This is mainly used to evacuate injured people from a vehicle in an accident

First the legs of the victim are released

Then the rescuer's arms are passed under the armpits of the victim.

With one hand, the rescuer grabs one of the wounded person's forearms

The other hand is used to hold the jaw of the injured person.

The move takes place.

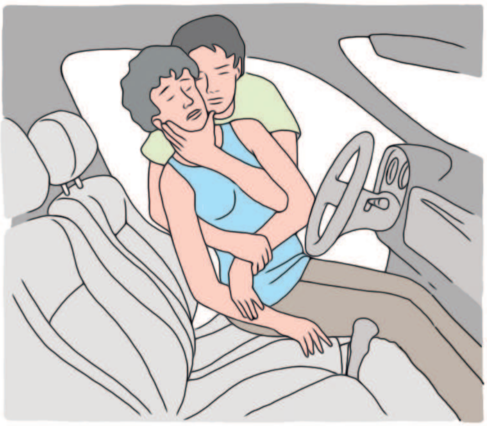


Figure 16.1. Rautek manoeuvre.

Simple drag

The injured person is straightened up, their clothing is grasped at shoulder (or armpit) level and at the same time the head is immobilised laterally with the forearms, then the injured person is dragged away with care so as not to hyperextend or hyperflex the neck **(B)**[229]. Be careful with shoulder injuries.

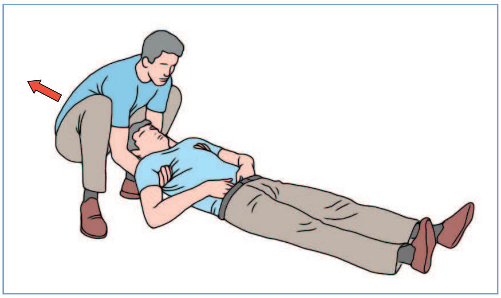
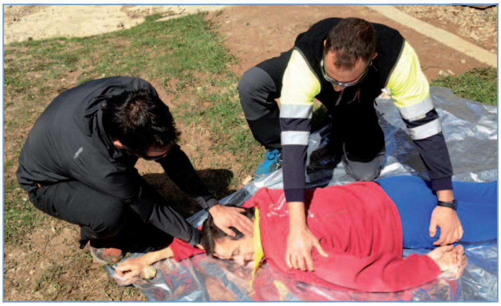


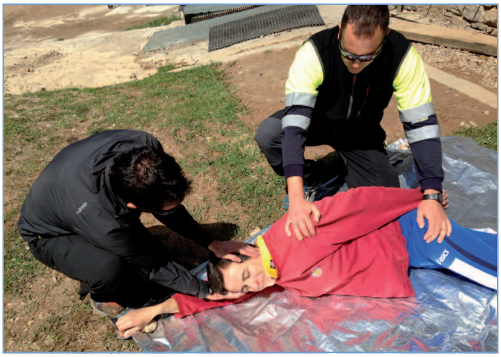
Figure 16.2. Simple drag.

The flip

The technique of flipping is used to move between the prone and supine positions.

The lead rescuer will immobilise the cervical area, the assistants will straighten the injured person, place themselves with one or two knees on the floor holding the part of the body that will be turned over (shoulders, pelvis, knees). The leader places their hands so that their forearms will be uncrossed at the end of the turn (to avoid this, sometimes you have to place your hands crossed at the beginning of the turn so that they are uncrossed when the turn is performed).





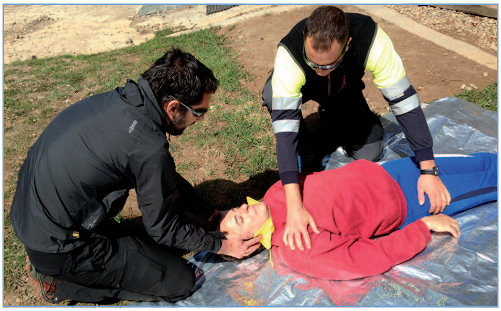


Figure 16.3, 4 and 5. The flip.

Slower moves

They prioritise the immobilisation of the spinal column while respecting the head-neck-stem axis.

If a bucket stretcher (first choice) is not used, the technique of choice is the improved straddle lift.

The patient is placed in a straight recumbent and position. The leader is in charge of the control of the cervical area and gives the orders. Stronger rescue workers are placed in the most weight-bearing position (shoulders, trunk, pelvis). Rescuers are positioned in order of height (the shortest one is placed at the knees) to avoid losing the alignment of the injured person. To avoid injury, the lifters bend their knees, but keeping their spines straight and vertical.

Simple straddle lift: perfected

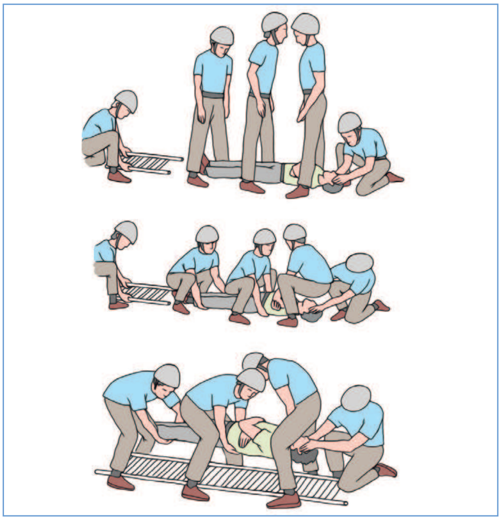


Figure 16.6. Perfected straddle lift.

MOVING AND IMMOBILISATION EQUIPMENT

Cervical collar

Routinely applying a cervical collar or bilateral sandbags to limit cervical spine movement is not normally recommended because the benefits do not outweigh possible adverse effects, especially endocranial hypertension and airway involvement **(B)**.[198]

If it is used, the characteristics and the correct fitting method must be known.

Characteristics

- They limit flexion-extension by 90% (sufficient protection).
- They limit lateralisation and rotation by 50% (insufficient protection).
- They should not make it difficult for the patient to open their mouth.
- They should not obstruct or hinder ventilation.
- They should not exert excessive pressure so as not to hinder the return circulation.

How to apply the collar

Two rescue team members are necessary. They should be in a comfortable and stable position to avoid sudden movements.

Expose the neck by removing objects, pendants, clothes, hair, etc.

Look for deviations (deviation of the trachea, subcutaneous emphysema, jugular ingurgitation, etc.)

Maintain a neutral position by two handed alignment stabilisation

While one rescuer stabilises with both hands, the other one chooses the right size of collar (which does not produce flexion or extension of the neck).

While maintaining manual stabilisation, the second rescuer applies the collar by passing its tongue behind and adjusting it so that the cleft is at the bottom of the chin.

Remember that the placement of the cervical collar does not guarantee a neutral position of the cervical segment.

If there is pain, neurological deficit or airway or ventilation involvement when the neck is placed in a neutral position, immobilise in the position in which it was found.

A cervical collar can increase the intracranial pressure and reduce the passage of air through the airways. This can be avoided in conscious patients with no signs of toxicity, who do not have neurological symptoms, pain on cervical palpation or any other injury that may mask a cervical trauma, as well as in patients whose cervical spine is immobilised by other means. **(B)**. It is contraindicated in patients with ankylosing spondylitis **(A)**.[229-232]

Scoop stretcher

The device of choice for picking up or transferring an injured person to another restraining device (e.g. vacuum mattress) or to move them on flat surfaces. It is a stretcher that can be opened by the middle area and closed in the shape of a pair of scissors, facilitating the collection of the injured person with minimal movement. It is composed of a metal support formed by two symmetrical parts in its longitudinal axis and is articulated at both ends. It is adjustable for height.

How to apply it

- Adjust the height of the stretcher to suit the size of the patient.
- Apply manual in-line stabilisation.
- Place the patient on their side.
- Insert the corresponding half of the stretcher under the patient.
- Repeat the manoeuvre on the opposite side until the two halves of the stretcher have been fitted together.

Transfer from the scoop stretcher to the vacuum mattress

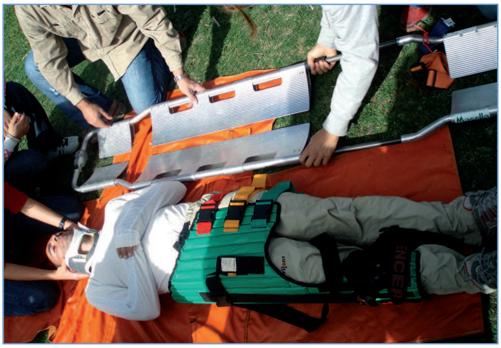


Figure 16.7. Scoop stretcher.

- Place the patient on the spoon stretcher.
- Lift without moving horizontally.
- Place the vacuum mattress.
- Lower the scoop stretcher onto the vacuum mattress.
- Remove the scoop stretcher.
- Immobilise with the vacuum mattress.

Vacuum mattress

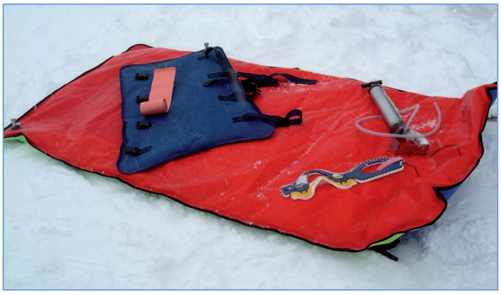


Figure 16.8. Vacuum matress and splint, mouldable splint and cervical collar.

This is the method of choice for immobilising **(B)**.[229 230] It is made of a nylon wrap filled with polystyrene spheres that adapt to the shape of the body. The vacuum is formed with a pneumatic pump so that the pellets are squeezed together until they reach sufficient rigidity to immobilise the injured person.

Advantages

- Thermal insulation and vibration absorption.
- Maximum adaptation, therefore, maximum immobilisation.
- Reusable.
- Easy to clean.
- Relatively light.
- Radiolucent (transparent to X-rays).

Disadvantages

- Large volume (storage).
- The vacuum device can be punctured.
- High cost.
- Most models require a board or stretcher to maintain rigidity.
- Shrinkage in the last phase of deflation.
- Loss of consistency during air transport.

Method of use

- Preferably spread the vacuum mattress over a flat area then distribute the contents evenly.
- When working on an inclined area, extract the air until a certain level of rigidity is achieved in order to avoid unwanted volume displacement. This rigidity will also make it easier for the vacuum mattress to slide underneath the victim during the straddle lift manoeuvre.
- Place a rigid device under the mattress (rescue sled).
- Lift the patient using a spoon stretcher or straddle lift.
- Place the vacuum mattress together with the rigid device (rescue sled stretcher).
- Lower the injured person onto the mattress.
- After placing the injured person on it, the material inside the mattress will expand around the areas to be immobilised. If air has been previously extracted, the valve must be reopened.
- Adjust the mattress to the patient.
- Apply a vacuum is with the suction pump to stiffen the mattress, thereby immobilising the patient.

Kendrick extrication device (Ferno-KED)

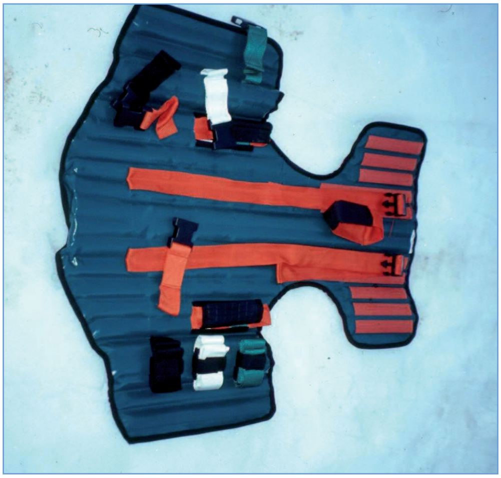


Figure 16.9. Ferno KED.

Ferno KED is an immobilisation system consisting of articulated slats with a canvas cover and straps for fastening the patient. It is used to immobilise the trunk-neck-head axis although, if there is no other more suitable device, it can also be used inversely to immobilise hip and proximal complete femur fractures. It can be used in conjunction with the vacuum mattress for better protection of the cervical spine.

How to use it

Once the manually aligned stabilisation has been carried out and the cervical collar has been fitted, the injured person is placed in a vertical position, creating sufficient space behind the back.

Insert the Ferno-KED until the bottom edge is flush.

Fasten the torso straps starting at the bottom and continuing through the middle. Leave the top ones unbuttoned.

Adjust the straps by passing each one under the corresponding leg. During this step, the height of the Ferno can be adjusted if it is not ideal.

Fill in the gap between the injured person's head and the Ferno-KED and then secure the corresponding front and chin fastenings.

Finally, adjust the upper chest strap and check the others before moving the injured person.

Vaccuum splints

These are immobilising devices based on the agglutination of the filling material after extracting the air by means of an extraction system that creates a vacuum.

They can be used alone in cases of isolated limb injuries, but are usually used in conjunction with the vacuum mattress.

Advantages

- Thermal insulation and vibration absorption.
- Maximum adaptation and therefore maximum immobilisation.
- Reusable.
- Easy to clean.
- Relatively light.
- Radiolucent.

Disadvantages

- Large volume (storage).
- The vacuum device can be punctured.
- High cost.
- Most models require a board or stretcher to maintain rigidity.
- Shrinkage in the last phase of deflation.
- Loss of consistency during air transport.

Method of use

- Preferably spread the vacuum splint over a flat area and distribute the contents evenly When working on an inclined area, extract the air until a certain level of rigidity is achieved in order to avoid unwanted volume displacement.
- Elevate the affected limb en bloc.
- Insert the vacuum splint.
- Adapt the splint to the limb. If air has been previously extracted, the valve must be reopened.
- Apply a vacuum with the suction pump causing the splint to stiffen, thereby immobilising the limb.

Mouldable splints

Are made of mouldable metal sheets covered with foam. They are very manageable in the mountains.

Advantages

- Radiolucent.
- They adapt to any part of the body.
- They are easy to clean and disinfect.
- They can be easily trimmed.
- They occupy little space and are lightweight.
- They avoid thermal bridging; they do not absorb moisture.

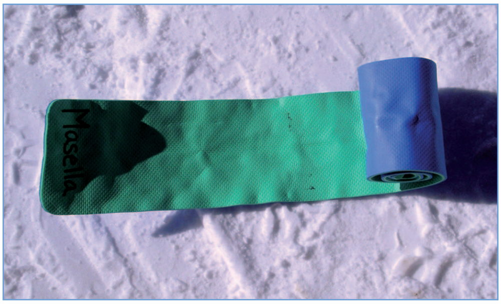


Figure 16.10. Mouldable splint.

Spinal board

This is a rigid board. It can be used on short trips (less than 30 minutes) to avoid compression injuries.

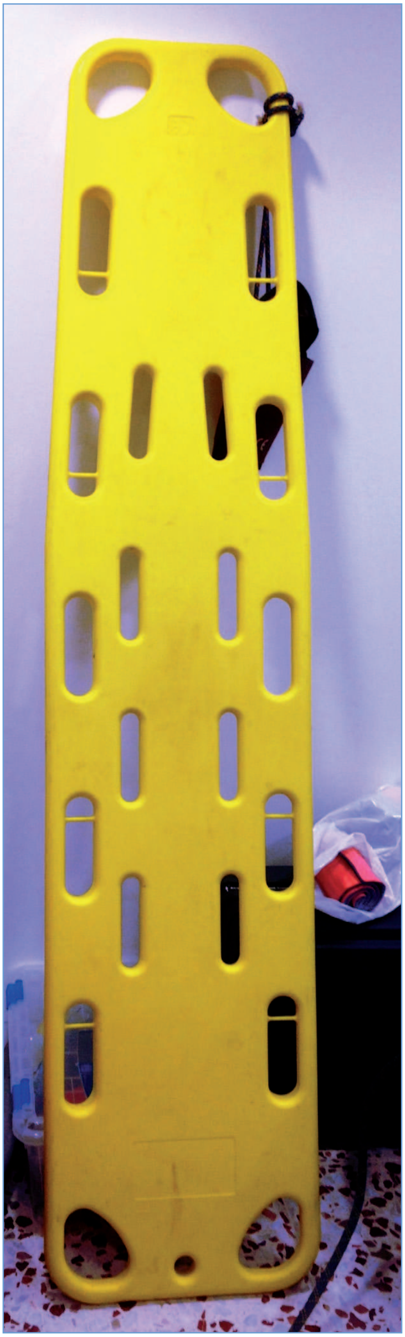


Figure 16.11. Long spinal board (LSB).

Pelvic sling

Used to immobilise complete pelvic fractures with hemodynamic instability.[224]

Bleeding associated with complete pelvic fractures can occur directly from the fractured complete bone, from the pre-sacral venous plexus, or from the iliac vessels. The use of pelvic slings is effective in restoring normal bone anatomy and may reduce bleeding volume, but may also cause local tissue damage. The results of studies on the benefit of their use are heterogeneous, and more studies are needed to determine their efficacy in reducing mortality or bleeding in unstable complete pelvic fractures.[225]

If complete pelvic fracture (pain) is suspected, the pelvis may be closed with a pelvic sling to reduce pelvic volume and try to minimise bleeding.[224]

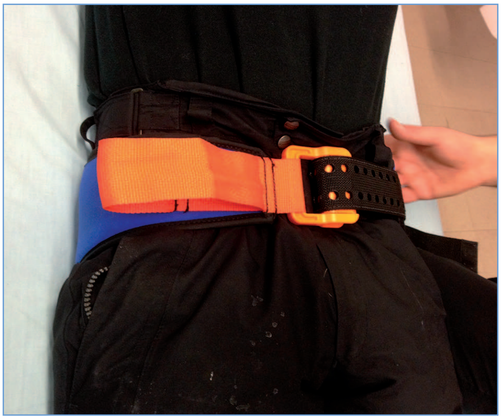


Figure 16.12. Pelvic sling.

EVACUATION

Evacuation to the hospital is usually by land or air.

If terrestrial means are used, the injured person is usually brought down to an ambulance or vehicle in a stretcher carried on the shoulders (Piguillem stretcher).

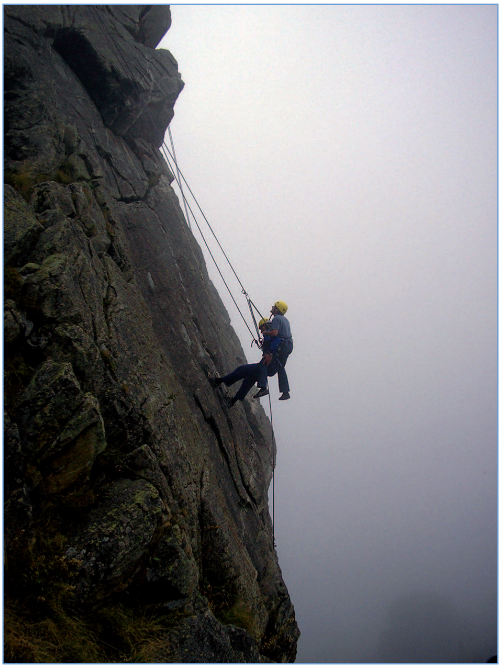


Figure 16.13. Evacuation from a wall.

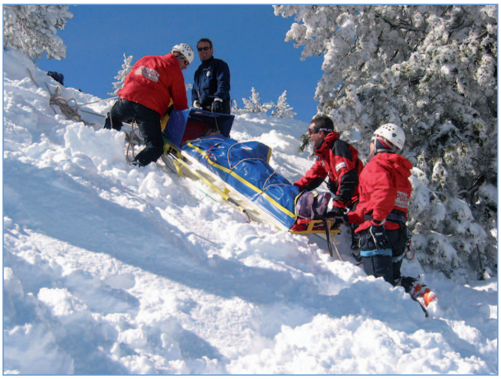


Figure 16.14. Evacuation from snowy terrain.

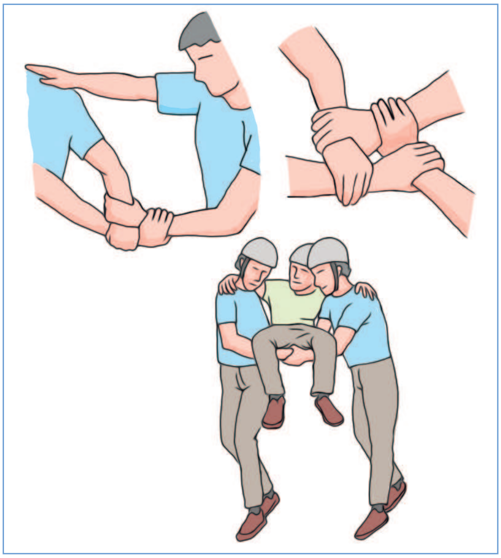


Figure 16.15. Evacuation using the chair method.

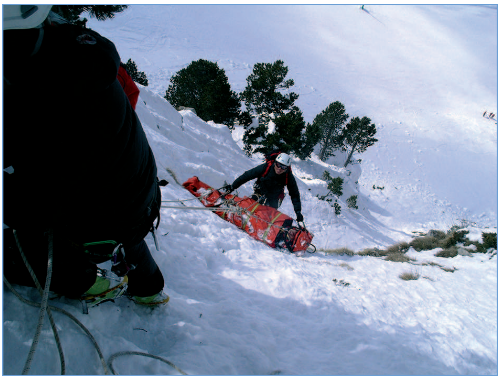


Figure 16.16. Evacuation from snowy terrain with a steep gradient.

17 ANALGESIA AND SEDATION

Treatment of pain is a priority, or it may worsen the clinical situation by causing hypoxemia (e.g. superficial tachypnea due to complete rib fractures), deterioration of shock (e.g. vasovagal reflexes causing hypotension) and neurohormonal stimulation causing circulatory disturbances and multi-organ failure **(C)**.[233]

A recent study of 1200 trauma patients found inadequate analgesia in 43 of them.[234]

Pain is an individual experience influenced by multiple factors. It can be assessed using the Verbal Number Rating Scale (VNRS).

Table 65: Verbal Number Rating Scale

Degree of pain	Score
Absent	0
Mild	1-3
Moderate	4-6
Severe	7-10

TREATMENT OF PAIN[234-235]

Non pharmacological measures

- Psychoanalgesia: an empathic attitude, an ethical use of the placebo effect and the minimization of the nocebo effect relieves pain **(A)**.
- Immobilisation: if complete fractures are suspected, immobilisation improves pain.
- PRICE **(A)**.
  - Protection to prevent the injury from getting worse and provide stability (bandaging, splints).
  - Rest to reduce swelling and pain.
  - Ice to reduce oedema and reduce skin temperature to 15 °C, where nerve conduction is inhibited and pain is reduced. It is performed at 10-minute intervals for the first 24 to 48 hours.
  - Compression with elastic bandage, to reduce oedema.
  - Elevation of the injured area to reduce oedema.

Non-opioid analgesics

The combination of **paracetamol** (1 g) with **NSAIDs** (e.g. ibuprofen 400-600 mg) every 6-8 h is the treatment of choice. Daily doses of paracetamol below 4 g/d or ibuprofen below 1200 mg/d do not cause more adverse effects than a placebo (Grade A recommendation).

Paracetamol combined with codeine or tramadol is discreetly more effective, although some guidelines advise against it because of its greater adverse effects **(A)**.

Parenteral NSAIDs are not more effective nor do they produce fewer adverse effects than oral NSAIDs **(A)**. The most commonly used are dexketoprofen 50 mg every 6 hours (adults) or ketorolac 10-30 mg IM or IV (60 mg IM, equivalent to ibuprofen 800 mg oral).

Topical NSAIDs (except indomethacin) are effective in treating sprains and strains and traumatic corneal abrasions.

Inhaled agents

Nitrous oxide is an effective analgesic **(B)**. Neuropathy and bone marrow suppression are rare complications. There are no controlled studies on the maximum duration or number of times a patient can be safely exposed to nitrous oxide.

Methoxyflurane, in low concentrations, is an effective and safe fast acting analgesic **(B)**.

NMDA receptor antagonists

Ketamine is a safe and effective analgesic in the prehospital setting **(B)**. The injured person loses consciousness, but continues to have open eyes and may have nightmares during anaesthesia and for the next two hours. It does not cause cardiorespiratory depression, increase intracranial pressure, or reduce cranial perfusion pressure compared to opioids **(A)**.[236-241]

Ketamine IV reduces the use of opiates **(A)**.

(S+) Ketamine, which is the levorotatory component of the racemic mixture used in Spain, is more powerful and has fewer undesirable effects **(B)**.

The dose used to obtain mild analgesia and sedation during an evacuation of an injured person is 0.5-2 mg/kg by intramuscular route.

Opioid analgesics

Oral opioids (hydromorphone, oxycodone), less used in mountains **(B)**.

Oral transmucosal fentanyl **(B)**.

Intranasal fentanyl: provides better and faster analgesia than the oral transmucosal form (Grade A recommendation).

IM fentanyl **(B)**.

Fentanyl IV or IO **(A)**.[242 243 244-247]

Morphine IV 0.05-0.2 mg/kg.

In the treatment of acute pain, one opioid is not superior to others, but some opioids are better in some patients. The incidence of clinically significant adverse effects (nausea, vomiting) is dose-related **(B)**.

Shock, oedema and hypothermia may make it difficult to absorb analgesics subcutaneously or intramuscularly, so the intravenous route will be preferred in these cases.

The opioid antagonist is naloxone administered at a dose of 0.1-0.2 mg V every 2-3 min.

Table 17.1. Most commonly used analgesics to treat severe pain

	Fentanyl	Ketamine
Dose	IV: 0.5-2 µg/kg Moderate pain: 25-100 µg in 1-2 minutes, repeat at 1-2 h if necessary Severe pain: 50-200 µg followed by an infusion of 25-50 µg/hour IM and intranasal: similar dose x 1.4 times the IV dose (100 µg) SL: 200-1600 µg (400 µg equals 5 mg morphine IV)	IV 0.25-0.7 mg/kg IM 0.5-2 mg/kg Combinations: with benzodiazepines to prevent nightmares (Midazolam 0.0015 mg/kg) and atropine to treat salivation (0.01 - 0.02 mg/kg, minimum cough 0.1 mg, which may be repeated every 5 minutes)
Action	IV: start: 1 min, maximum: 5 min, duration: 30-60 min IM: start: 7-15 min, maximum: 15 min, duration: 1-2 h SL: start 6-31 min; maximum: 20-40 min. Intranasal: maximum 12-15 min.	Start: IV: 30 sec- 3 min IM: 2-5 min Maximum: IV: 5 min Length: IV: 15 min IM: 30 min
Advantages	Very powerful. (100 times more potent than morphine)	Powerful. No significant respiratory depression. Bronchodilation, not vasodilatation. Preserves protective reflexes. No release of histamine, rare allergic reactions. No buildup, no organ-toxicity. Not subject to narcotics control.

Table 17.1. (Cont.) Most commonly used analgesics to treat severe pain

	Fentanyl	Ketamine
Disadvantages	Respiratory depression. Continuous monitoring.	Central sympathomimetic stimulation. Increased pulmonary arterial systiloc pressure and arterial pressure, cardiac output and myocardial oxygen requirements. It induces salivary secretion. Low hypnotic properties. nightmares and delusions (minimised with benzodiazepines). Contraindicated in coronary disease and hypertension, oculofacial trauma. Continuous monitoring.

In case of life threatening urgency, it can be administered by sublingual puncture with immediate effect. It may cause nausea, vomiting, diaphoresis, pain and HTN.

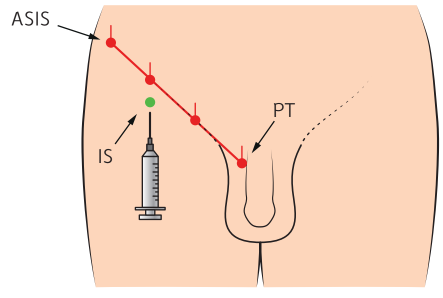
Local analgesia

Local analgesia (e.g. lidocaine 1%, mepivacaine) may be useful in complete fractures and soft tissue injuries **(B)**. The amount needed is usually: clavicle 4 mL, ankle and shoulder 10 mL, interdigital block: 2 mL without adrenaline.

Iliac fascia block

Is a more effective method than IV morphine for suppressing pain in an acute femoral complete fracture during transport, or immobilisation of the leg **(A)**.[248-250]

An iliac fascia compartment blockage involves the administration of local anaesthetic in the compartment formed below the iliac fascia in the lower limbs at the level of the ilioinguinal ligament. This technique blocks the femoral, femorocutaneous and obturator nerves. To establish the puncture site, a line is drawn between the anterior superior iliac spine and the ipsilateral pubic tubercle; the line is divided into three equal parts and the local anaesthetic is injected 0.5-1 cm below the junction between the external third and the internal two-thirds. The needle is inserted with a slight tilt. When the needle passes through the fasciae latae, a loss of resistance "plop" is felt, and when the needle passes through the iliac fascia, a second "plop" is felt. The anaesthetic (27.5 mL of bupivacaine for a 50 kg person) is injected at the same time as pressure is applied below the needle insertion site to promote cephalic migration of the solution. After removing the needle, a massage is performed towards the direction of the head to promote the spread of the anaesthetic.



ASIS Anterior superior iliac spine
PT: Pubic tubercle
IS: Injection site

Figure 17.1. Iliac fascia block.

Sedation

In cases of agitation, evaluate the administration of diazepam 5-10 mg or midazolam (initial dosage 0.5-1 mg/kg, maintenance dosage 0.05-0.4 mg/kg/hour) 2-5 mg (action: start

1-5 min, duration: 30-90 min). The effectiveness of the different sedatives is similar[251]

The benzodiazepine antagonist is flumazenil. The initial dose is 0.2 mg in 15 sec. To reverse the effects of benzodiazepines, additional doses of 0.2 mg may be administered every minute up to a maximum of 1 mg.

ANTIEMETICS

Ondansetron 4-8 mg may be used IV.

18

HELICOPTER EVACUATION[252, 253]

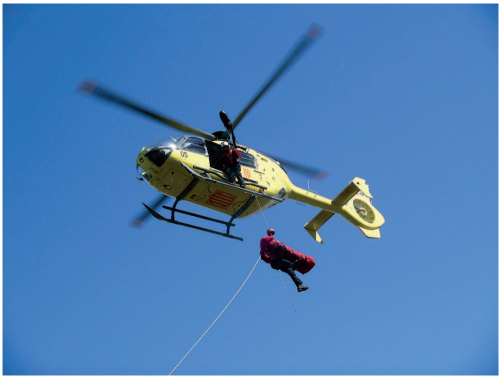


Figure 18.1. Helicopter evacuation by hoist.

Helicopters have helped to speed up mountain rescue, reducing the mortality of severe patients. **(C)**.[203]

Their main limitations are visibility, wind and air density. Rescues may be performed by hoist or with full or partial landing of the helicopter. For mountain flying, regulations indicate the use of category A helicopters, which are multi-engine helicopters capable of safely continuing the flight to an appropriate landing area in the event of an engine failure (Class 1 performance operation).

Helicopter Emergency Medical Service (HEMS) crews must meet the training requirements published in the Joint Aviation Requirements - Operations 3 (JAR-OPS 3), developed and agreed by the Joint Aviation Authorities (JAA), with the aim of unifying at European level the requirements for the operation of civil helicopters ((Spanish -Royal Decree-279/2007).

HEMS crews should be trained in the following aspects:

- Functions assigned within HEMS.
- Navigation (map reading, principles and use of navigation aids).
- Operation of radio equipment.
- Use of medical equipment on board.
- Preparation of the helicopter and specialised medical equipment for the subsequent HEMS departure.
- Instrument reading, warnings, use of normal and emergency checklists to assist the pilot if necessary.
- Basic knowledge of the type of helicopter in terms of location, design of the normal and emergency systems and equipment and of its other equipment.
- Crew coordination.
- HEMS call response practices.
- Refuelling and refuelling with the rotors running.
- Selection and use of HEMS operating sites.
- Patient management techniques, medical consequences of air travel, and some knowledge of hospital emergency unit reception.
- Signalling marks and signs.
- Loading operations on the sling if necessary.
- Rescue hoist operations if necessary.
- Dangers to yourself and others when the helicopter rotor is running, including patient loading.
- Use of the helicopter intercom system.

SAFETY STANDARDS WHEN USING A HELICOPTER

Before the arrival of the helicopter

Try giving the following information

- Identify the place of the accident, using references that can be easily recognised from the air to facilitate its location: relative position with respect to high voltage lines, antennas, singular or especially visible buildings.
- Ground conditions and approximate altitude.
- Number of accidents and diagnostic orientation.
- Weather conditions in the area, especially visibility and wind.

Prepare a landing area

- Look for a sufficiently large area (e.g.: 20 meters in diameter with a flat space of about 4 meters).
- Free of obstacles that may prevent or hinder the landing: power lines, trees, antennas, etc.
- Free of flying objects as a result of the downwash produced by the rotors.
- Adequate access from the accident site
- The ground should be as flat and firm as possible and free of dust. If it is on a slope, it cannot exceed 7º or 13%.
- Better on a mound than in a hollow.
- Avoid areas downwind of slopes and mountains if the wind is strong.
- If necessary and whenever possible, an attempt shall be made to adapt the type of surface area to the arrival of the helicopter: watering dusty surfaces, compacting powdered snow, clearing bushes or branches, collecting objects and materials that are liable to be blown around.

When the helicopter arrives, the noise and downwash produced by its rotors will make communication difficult, so it is advisable to take advantage of the moments prior to arrival to establish and coordinate the necessary measures to ensure the safety of the operation: a) assign functions to the people who will remain close to the helicopter's point of operation, b) keep away all those who have no specific mission and c) prepare the injured party in a somewhat remote location to avoid the inconvenience inherent to the helicopter's arrival.

Ground signals

If the helicopter does not see you, but you see it, you can guide it on your position by mobile phone in the following way: imagining that the helicopter is a clock and that the pilot is looking out at 12 o'clock, tell it what time we are from its point of view (for example, 'We are in your 3 o'clock').

To signal the position, a single person is placed facing the area considered most suitable for landing, with their arms extended upwards so that their body forms the letter "Y" and with their back to the wind, in order to indicate the relative wind direction at that point to the pilot, so that when the helicopter approaches into wind the pilot and the person signalling the area are face to face. When the helicopter is close to the ground, the pilot shall be instructed to approach safely.

If the helicopter pilot decides to land from a different direction than the one proposed, adapt your position to the new trajectory, in order to keep facing the pilot until the moment of touchdown. If possible, hold a handkerchief in one hand to visually indicate the intensity of the wind in the area.

If, for any reason, you do not want the helicopter to land, the 'N' position shall be adopted, with one arm up and the other arm down, both slightly separated from the axis of the body.

During landing, except for the signalling person, all other people shall remain outside the landing area, within the pilot's scope of vision, without making any unnecessary signals.

Also, if there is a lot of dust or snow during the approach, the person signalling may take cover or bend over, but it is important that they do not move away from their position because, if visibility is reduced, they may be the only point of reference for the pilot.

Conduct around a running helicopter

In mountain rescue, the turbines and rotors of the helicopter often do not stop, so it is essential to take extreme precaution when you are near it. This is especially important when the helicopter has to remain in low stationary flight or partially grounded, as it is extremely unstable in these cases.

No one should approach the helicopter without being absolutely certain that they have been authorised to do so by the pilot or another crewmember. Be careful to carry long objects (avalanche probes, skis, etc.) horizontally and parallel to the ground.

Do not wear clothing (caps, etc.) that may be blown away by the action of the rotors. Secure the blankets or anoraks covering the injured person (especially the thermal blankets because of their lightness). Also, objects with a large surface area (stretchers, vacuum mattresses, etc.) must be transported between at least two people, to prevent behaving like a sail.

The approach to the helicopter shall always be made in view of the crew and in the front sector, NEVER in the tail rotor area, even if this involves a long detour.

If there is a slope, always approach from the bottom of the slope. Approach upwards and depart downwards.

In any case, whenever you approach a helicopter in motion, do it bent over.

In case of being picked up by the helicopter hoist, your backpack must be carried in you hand or hanging from the harness rappelling ring with a locking carabiner, and your ice axe must be carried in your hand.

The helicopter doors shall be operated by the crew only.

If the helicopter is unstable and the injured person needs to be loaded or unloaded, do so diligently but gently, avoiding sudden loading or moving of weights inside the helicopter to avoid destabilising it. Never pull on the helicopter. When it is in stationary flight, its lift is just enough to counteract the force of gravity and it is literally weightless. You could inadvertently move it.

When disembarking from a helicopter in motion, if it is to take off after, visually check the safety of the environment, especially the areas not visible to the crew and give the pilot the OK with a thumbs up.

Rules on board the helicopter

Do not touch anything or anyone inside the helicopter. Strap yourself in and put on your headphones, avoiding speaking during the transmission or reception of communications via the different communications equipment. Inspect the fastening anchors of the material under your responsibility.

It is desirable for all crew members to cooperate actively in the safety of the aircraft and especially in the detection of obstacles dangerous to the flight (high voltage power lines, etc.).

The crew consists of

- The aircraft commander, who is the highest authority and ultimately responsible for all decisions made in the helicopter, except those directly related to health care.
- The rest of the technical crew: co-pilot, flight engineer, hoist operator, or loadmaster.
- Health workers (HEMS): are considered to be part of the crew and, when required to do so by the Commander of the aircraft and in addition to carrying out their healthcare functions, they must collaborate in maintaining the safety of the aircraft, both in flight, on the ground and during any other task related to its operation.

Specific precautions

Extreme care must be taken to avoid unintentional handling of flight controls, switches, door handles and other items whose unintentional use may cause safety problems. Agitated patients should be sedated before the flight. If security cannot be guaranteed, the transfer will be delayed or cancelled.

Oxygen for medical use represents a potential hazard. Precautions must be taken in its transportation, installation and handling due to its high flammability. Open the valve on a bottle a quarter turn at the most; this will be sufficient to ensure adequate flow and make it easier to close the oxygen outlet. If it is only opened a quarter turn, you will immediately notice if you are closing it in the right direction. Oxygen reacts by deflagrating on contact with grease; after providing primary assistance with the presence of grease from the accident vehicle, gloves must be changed before handling the on board oxygen.

Consult with the aircraft Commander before using the helicopter's electrical system to connect medical equipment.

It is important to know the location and operation of some on-board safety equipment, such as:

- Door release levers, which release the helicopter doors in cases of emergency evacuation.
- Fire extinguishers.
- Radio beacons: aircraft are equipped with emergency communication equipment or Emergency Location Transmitters (ELTs) which can broadcast either manually or automatically on an agreed pre-set distress frequency, which is always the same. In the event of an accident, this device would be activated by the effect of impact g-forces and would facilitate location of the aircraft
- First aid kit.

The crew must be trained to evacuate the helicopter in the most appropriate manner, if necessary.

Safety during transport

Throughout the approach and in particular during the landing phase, all crew members shall monitor their respective visual quadrant, depending on their position in the helicopter, in order to be able to alert of the presence of possible obstacles or other potential dangers to the manoeuvre.

If the medical staff considers that a quick landing is foreseeable in order to carry out specific procedures on the patient, they shall alert the pilot in advance so that he can steer the flight in the most appropriate manner. Prior to take-off, the medical crew will also comment on the patient's condition in order to adapt the flight to their characteristics (keep the altitude as low as possible, minimise movement, etc.).

When the helicopter lands, the doctor, with the pilot's permission, will descend and check that there is no potential danger around the aircraft. Then he will go to the injured party's location to assess the case and begin assistance.

In the meantime, the nurse shall disembark and be responsible for the external safety of the helicopter until idling speed has been reached and after the rotors have been stopped, pilots can do this themself or by delegating to an authorised person.

The helicopter must remain on idle for between 30 seconds and two minutes (depending on the model). If during this time, the doctor determines that medical intervention is not necessary, the pilot will be informed and therefore won't stop the engines, in order to avoid the delay and the possible risk of a hot start. Communication shall take place by mobile phone, by radio, or by visual signals:

- A hand stretched out horizontally "cutting" the neck to indicate a request to stop.
- A forearm extended upward with the index finger circled to indicate to start or keep running.

Once the engines have stopped and the safety of the helicopter has been entrusted to an authorised agent present at the site, the pilot will assist the medical personnel, especially with regard to the equipment they may require. The pilot will collect the necessary data from the doctor to inform the head office of the circumstances of the accident and the diagnostic approach of the injured, in order to activate the necessary auxiliary means and coordinate the transfer to the most appropriate destination hospital.

Health workers will prepare the patient for movement by attaching them to the stretcher, but with all cables, tubing and perfusion systems free and outside the restraint straps. They will secure the airway and the tubing, check the sera and put headphones on the victim to protect them.

The pilot shall direct the loading of the injured person, ensuring that it is done safely and that both the stretcher and the on board equipment are properly secured on board the helicopter.

Prior to take-off, ground staff shall be notified to ensure the safety of the environment until take-off is completed.

Upon arrival at the receiving hospital, the unloading will be carried out in a similar manner, making sure that the ambulance does not approach until it is authorised to do so, normally with the rotors already stopped. The two teams (air and ground) will participate in the unloading and, once inside the ambulance, relief will be carried out if appropriate.

Figure 18.2. Stationary flight evacuation.

PATHOPHYSIOLOGY OF HELICOPTER TRANSPORT

During transport by helicopter, the injured person is exposed to a drop in barometric pressure which will can cause:

Reduced oxygen availability

The proportion of gases remains constant at any altitude (78% nitrogen, 21% oxygen, 1% other gases), but their partial pressures decrease with altitude. The body tries to compensate for this decrease by increasing cardiac output and respiratory rate, which means a significant energy expense that can worsen the situation of the injured person, especially if they have a respiratory pathology, ischemic heart disease, anaemia or any process that requires an increase in oxygen consumption. Therefore, the need for additional oxygen during the flight must be assessed.

Table 18.1. Transfers at risk due to hypoxia

- Shock
- Thoracic trauma with unstable thorax, hemothorax, pneumothorax, complete multiple rib fractures
- Shockwave injuries
- Acute coronary syndrome
- Acute pulmonary oedema
- Acute respiratory failure
- Pulmonary thromboembolism
- Asthma
- Pneumonia
- Spinal cord injury
- Increased intracranial pressure
- Extensive burns

Table 18.2. Oxygenation level according to altitude

Altitude (metres)	Arterial oxygen (mmHg)	SpO_2 (%)
0	95	97
2,400	56	89
3,600	43	78

Gas expansion

According to Boyle-Mariotte's law, volume is inversely proportional to the pressure: V.K * T/P; where V is the gas volume, P is pressure, T is the temperature (which remains constant around 37 °C) and K is a constant.

The decrease in atmospheric pressure produced by altitude causes gasses to expand with the following consequences:

- Increased volume trapped in undrained pneumothoraxes .
- Aggravation of mediastinal emphysema and expansion of residual air accumulations not reabsorbed after thoracotomies.
- An increased intracranial pressure in patients with pneumoencephalon. Cranioencephalic trauma that has caused a connection with pneumatic cavities such as mastoid cells, sinuses, middle ear, can cause an increase in intracranial pressure.

- Increased intraocular pressure.
- Ruptured tympanic membrane and barosinusitis.
- Distal ischemia after immobilisation with a plaster cast.
- Distension of the gastrointestinal tract: worsening of intestinal ileus, dehiscence of sutures and abdominal anastomosis in post-surgical patients due to the expansion of the wound and sutured area, reactivation of digestive haemorrhages, intestinal perforation, etc.
- Increased diaphragmatic pressure due to a distension of the intraluminal gas may cause dyspnoea during flight.
- Aerophagy.
- Risk of vomiting.
- And, in general, alterations in all those structures containing gas.

These effects caused by low atmospheric pressure could already be significant at 2000 m, where the volume of gases increases by 30%.

Open body cavities, such as the lungs, are balanced with the adjacent atmosphere so that no pressure changes occur.

Tips to avoid or improve barotrauma

- Barotitis is the most common condition during flight. During the ascent, the external pressure decreases and the pressure of the middle ear increases; the eardrum is pumped into the external auditory canal until the pressure gradient is such that it opens the Eustachian tube and the pressures are equalised with the sound of an opening click. During the descent, the external pressure increases and the eardrum bulges towards the middle ear causing intense pain. In order to permeate the communication between the middle ear and the oropharynx, manoeuvres such as swallowing, moving the jaw or the Valsalva manoeuvre may be performed (not recommended because opening the Eustachian tube towards the middle ear may cause contaminated pharyngeal mucus to develop). If intense otalgia occurs, the ascent is restarted until the pressure is equalised and the pain disappears and the descent is repeated gently.
- Barosinusitis, usually of the frontal and nasal sinuses, improves with the Valsalva manoeuvre.
- Barodontalgia can be prevented by maintaining good dental hygiene and treating cavities.
- Abdominal baropathy is common and is prevented by avoiding aerophagy (flatulent foods, smoking, eating fast, etc.).

The increase in pressure produced by gas expansion will also affect the medical equipment:

- Increases the pressure of the drip systems with a decrease in the spontaneous rate of infusion of the sera, so use plastic containers.
- Air should be replaced with a saline solution in endotracheal tubes pneumopericardium tamponading and Foley catheter retention balloons (intravesical or in other locations), to prevent the expansion of the more commonly used air.
- Swan-Ganz catheters will deflate.
- Continuous suction devices (Pleur-evac) should be replaced by Heimlich valves or connected to a low-pressure vacuum pump.
- Mattresses and vacuum splints will also be affected, decreasing their consistency due to the increase in air volume, so it will be necessary to check their hardness. Complete pneumatic fracture immobilisation splints are not recommended for air transport. It will be necessary to make a longitudinal cut in the gypsum for traumatological pathology, to avoid a possible distal ischemia by compression of the affected limb.
- Altitude increases gas expansion, so the oxygen cylinders do not have to be filled to maximum.
- The environmental characteristics mentioned above reduce the reliability of the entire physical examination (inspection, palpation and auscultation in particular), non-invasive blood pressure methods should stimulate the suspicion that they do not adequately reflect the correct values.

ACCELERATION AND DECELERATION

The response capacity to withstand an acceleration or deceleration depends on the intensity of that acceleration or deceleration, measured in 'G', which is the value of the force of gravity at sea level (9.8 $m.s^{-1}$). Accelerations in aircraft range from 0.5 G at take-off in an aeroplane to 0.1-0.3 G in helicopters, which is lower than in land vehicles. These accelerations may be more important in the transverse and vertical axis, so it is recommended that the patient is placed on the longitudinal axis of the aircraft, with their head facing backwards and their feet in the direction of travel.

Classification of acceleration

- positive longitudinal acceleration (+ Gz), in head-to-toe direction.
- negative longitudinal acceleration (– Gz), toe to head.
- positive transverse acceleration (– Gx), perpendicular to the longitudinal axis and in the anteroposterior (front to rear) direction.
- negative transverse acceleration (-gx), in the posterior-anterior (rear to front) direction.
- positive and negative lateral acceleration (± Gy), from right to left and vice versa, of little clinical importance in aviation, only at experimental level.

Effects of positive longitudinal acceleration

- Decreased mobility as a result of increased body weight
- Arterial hypotension with tachycardia secondary to baroreceptor stimulation, a reflex syncope is less well tolerated if exposure to increased g is abrupt. Heart rate and blood pressure depend significantly on the patient's position. With the feet to the front, in the direction of travel, there is a decrease in heart rate that persists during acceleration; the other way around, placing the head in front of the heart will produce an increase in heart rate and the blood pressure will suffer an inverse effect to that of the heart rate. Haemodynamic instability makes it advisable to transport in a transverse position as far as possible. This is also the transport position recommended for term pregnancies (in addition to the lateral decubitus position, preferably the left one, to avoid overpressure in the inferior vena cava).
- Visual apparatus: blackout due to lack of perfusion of the receptors (cones and sticks) because of hypoperfusion of the central artery of the retina (around 4-5 G); this phenomenon is preceded by "tunnel vision" which is the concentric reduction of the visual field and "greyout", also due to hypoperfusion of the central artery of the retina but of a lesser intensity.
- On a neurological level, there may be a loss of consciousness, preceded by visual symptoms, due to changes in brain circulation.
- Changes in internal hydrostatic pressure: the movement of internal fluids and organs can cause unpleasant sensations and, in extreme cases, cause some type of bleeding. Hypovolemic patients are more sensitive to accelerations and decelerations.
- Distortion of elastic tissues: a sudden deceleration can cause disinsertion and serious damage to internal organs.
- Longitudinal acceleration varies the perfusion of microdrops, so infusion pumps should be used, especially in the administration of vasoactive drugs, nitroprusside, etc.
- Turbulence causes sudden jolts that can turn the patient, transport personnel and material into projectiles if they are not properly secured by safety belts or straps. It can increase the patient's anxiety, cause motion sickness, punctual increases in intracranial pressure in severe head injuries and increase pain in polytrauma patients. In transfers predictably affected by turbulence, increased sedation and/or analgesia of the patient is recommended in addition to prophylaxis for motion sickness.

VIBRATIONS

Biologically dangerous vibrations are between 4-12 Hz and cause resonance phenomena that cause tissue damage. Helicopters produce vibrations between 12-18 Hz, depending on the number of rotor blades; more blades will produce higher frequency vibrations with less potential for damage. Commercial aircraft produce higher frequency vibrations. Ground transport by ambulance causes vibrations of 4-16 Hz, which is in the most harmful range.

The most common symptoms are: shortness of breath, thoracic pain, abdominal pain, jaw pain, low back pain, rectal/bladder tension, headache, etc.

Organs subjected to the effect of vibrations can suffer microvascular tears due to resonance phenomena that destabilise the molecular bonds. Isolated cases of arrhythmias or cardiac resonance decompensations have been reported.

NOISE

The noise level in a helicopter is between 90 and 110 dB in the cockpit. Sleep disturbances occur from 70 dB upwards.

Noise makes it difficult or impossible to monitor and evaluate blood pressure using a stethoscope, so both should be evaluated before starting the transfer and, if necessary, digitalised diagnostic equipment should be used to monitor haemodynamic constants.

Occasionally, otalgia or a ruptured eardrum may occur.

Headphones should be used as acoustic protection for the injured person.

Table 18.3. Acceleration, deceleration, noise and vibrations in the different means used as sanitary transport

	Acceleration Deceleration (g)	Vibration (Hz)	Noise (dB)
Aeroplane	0.1	High	60-70
Ambulance stopped with engine running	0.07	4	70
Ambulance at 40-90 km/h	0.87	4-16	75-80
Helicopter from 2 blades to multi-blades	0.1-0.2	12-28	80-93

TEMPERATURE

The helicopters are equipped with heating, although not always with air conditioning; it is advisable to equip them properly.

OTHER FACTORS

There has been a greater tendency to convulse in predisposed patients when evacuated by helicopter, due to the stroboscopic effect of the main rotor blades and navigation lights, so it is convenient to protect the eyes from sunlight in this type of patient.

Space and weight limitations must also be taken into account.

Motion sickness is also a work related risk, although susceptible people often take prophylactic measures.

PREPARATION OF THE PATIENT FOR TRANSPORT

- Do not evacuate without prior stabilisation of the ventilatory and circulatory systems.
- Be sure to prepare a large venous line accessible and safe.
- If you have a pneumothorax, place a drain with one-way valves.
- Immobilised the injured person with a vacuum mattress and secured them to the bench with straps. Cervical and dorsolumbar stabilisation on suspicion of possible spinal cord injury, mobilisation on a scoop stretcher or spinal board, to be removed after transfer to the vacuum mattress, and isothermal sheet.
- Check for correct immobilisation of complete fractures. It will be necessary to make

a longitudinal cut in casts due to traumatological pathology, to avoid a possible distal ischemia by compression of the affected limb.

- Acoustic protection and/or communication with the crew.
- ECG, SpO_2, CO_2, NIBP monitoring.
- Administer O_2 according to needs and flight altitude.
- Have full CPR material available.
- If under mechanical ventilation: decrease tidal volume when gaining altitude, monitor airway pressure and inflate the endotracheal tube with saline solution or water.
- Serums in a plastic container, monitor increases or decreases of drip by altitude.
- Use infusion pumps if vasoactive drugs are given.
- Use unidirectional valves at altitude, not closed drainage systems.
- Wrap up warmly or heating at high altitude.
- Sedate the patient to avoid anxiety.
- Evaluate the use of pre-flight antiemetics.
- Use the lowest possible flight ceiling, especially in decompression illness.
- Attention to the controlled mobilisation of the patient, both for loading and unloading.
- Prior to the flight, do not neglect the patient's physiological emergencies.
- Blood for transfusion and infusion sera should be in plastic containers that allow sleeves to be used to increase perfusion pressure and prevent rupture from shock or expansion of the gases they contain.

Figure 18.2. Helicopter evacuation in ski resort.

Table 18.4. Contraindications for transferring patients by helicopter

Absolute	• The flight is not safe. • Patient terminally ill or in an irreversible situation. • Acute infection or contamination in the contagious phase. • Aggressive or uncontrollable patient.
Relative	• Cardiorespiratory arrest. • Uncontrolled arrhythmia. • Decompression sickness (depending on altitude). • Gas embolism. • Gas gangrene. • Intestinal obstruction. • Thoracotomy or laparotomy in the previous 7 days. • Intracranial air. • Eye surgery in the previous 7-14 days. • Pneumothorax with high probability of in-flight deterioration. • Haemorrhagic CVA in the previous 7 days. • Anaemia with Hb <7 g /100 mL. • Acute haemorrhage with haematocrit <30%. • Massive MI. • Acute pulmonary oedema. • Unbalanced COPD. • Severe acute asthma. • Non-immobilised acute spinal cord injury. • Threat of imminent labour. • Acute psychosis. • Delirium.

HOIST RESCUE OPERATIONS

Some helicopters are equipped with a rescue hoist in order to position or recover the crew at a point where the helicopter cannot land.

Descent procedure

- When the rescue party member is sitting and secured in their flying position, the hoist operator hands them the hoist hook to hook it to their main anchorage or to their anchoring line.
- Once anchored to the hoist hook, the rescue party member releases the anchorage

of their flight position. Never let go of a safety anchor point before you have been secured to another point.

- The rescue party member sits at the door of the helicopter, with their backpack hanging on their back (if he or she prefers to carry it in this way) and waits for the hoist operator to assist in exiting the helicopter, hanging from the sling.
- The hoist operator gives the backpack to the rescue party member if they prefer not to carry it on their back, to hook it to the longest end of the anchorage line, hanging it under their legs.
- The hoist operator confirms that the position is correct, usually vertical to the receiving point, and begins to descend the rescue party member.
- Once the descent has begun, the rescue party member stretches out their arms and legs to adopt an “X” position, trying to increase their surface drag and avoid starting to rotate on the axis that is the hoist cable.
- When the rescue party member is just a few metres from the ground, they inform the hoist operator to provide a smoother reception.
- Once on the ground, when the cable loses tension, the rescue party member is unhooked from the hoist and informs the hoist operator of the end of the descent manoeuvre.

Ascent procedure

- The rescue party member informs the hoist operator that they are ready to receive the hoist hook.
- Wait for the hoist hook to touch the ground first and discharge the static electricity accumulated during the descent.
- The rescue party member places the hoist hook of the on their main anchorage and gives the ascent signal, attentive to the moment when the feet lift from the ground, so as not to lose balance.
- Once the ascent begins, the rescue party member extends arms and legs to adopt an “X” position, trying to increase the surface drag and avoid starting to rotate on the axis that is the cable of the hoist.
- When arriving within a few meters of the helicopter, they must pay attention to the hoist operator’s instructions and pay attention not to hit the skid.
- Once they have reached the helicopter door, they give the hoist operator the backpack hanging between their legs, which will be secured inside the cabin. If the backpack is on their back, they will sit at the helicopter door and remove it with the help of the hoist operator.

Operation with rescue stretcher

Once the patient has been immobilised and placed on the stretcher, the procedure is as follows:

- The rescue party member informs the hoist operator that they are ready to receive the hoist hook.
- Wait for the hoist hook to touch the ground first and discharge the static electricity accumulated during the descent.
- The rescue party member attaches the hook of the hoist to the main anchorage of the stretcher.
- Place a 7 mm, 50-70 m line at the foot of the stretcher to hold the stretcher in place during the ascent to prevent it from spinning. This line is always tucked inside the stretcher. It must be attached to a quick release system installed on the stretcher to release it quickly if an unexpected snag occurs.
- The rescue party member informs the hoist operator that they can start lifting the stretcher.
- Once the ascent begins, the line must be held firmly to stabilise the stretcher, but without exerting enough force to produce sudden pendulous movements that make it difficult to ascend.
- When the stretcher reaches the helicopter door, the hoist operator releases the line, drops it to the ground and secures the stretcher to the helicopter.

Ascent with an injured person or lifting two people

Sometimes two people have to be lifted up on the hoist cable (a rescuer or ski patrol member with an injured person or a rescuer with a ski patrol member).

The victim's harness or an evacuation triangle can be used to join the 2 people together.

If you are wearing a sling, a double anchorage line can be attached to the hook of the lift and the longer line can be attached to the victim's central ring of the sling by a locked carabiner, and the shorter line to the central ring of the patrol member/rescuer ski harness by a locked carabiner.

If an evacuation triangle is used, it is attached to the hoist hook with a carabiner.

Procedure

- The rescue party member informs the hoist operator that he is ready to receive the hoist hook and that he will lift 2 people.
- Wait for the hoist hook to touch the ground first and discharge the static electricity accumulated during the descent.
- The rescue party member places the hoist hook on their main anchorage and that of the injured person (evacuation triangle or harness).
- The rescue party member informs the hoist operator that they can start the ascent, paying attention to the moment when their feet lift off the ground, so as not to lose their balance.
- Once the ascent begins, the rescue party member will keep an eye on the injured person, reassuring and warning about not touching anything.
- When arriving within a few meters of the helicopter, you must pay attention to the hoist operator's instructions and pay attention not to hit the skid.
- Once at the helicopter door, the hoist operator secures the injured person with an adjustable anchor line and introduces them into the cabin.
- The rescue party member then enters the cabin with the help of the hoist operator, goes to their flight position and attaches to its safety anchorage before releasing from the hoist hook.

Communication from the hoist hook in case of not having a helmet with integrated communications

- Communication to the crane operator for further lowering: a movement of the arm with the palm downward.
- Communication to the lift operator in order to ascend: a movement of the arm with the palm upward.
- Communication to the crane operator that they are close to the ground and preparing for reception: arms crossed in front or hands on the hook of the crane.

HEMS PROGRAMME ACCIDENT RATE

In the United States, during the 2003-2004 period, there were 4.8 accidents per 100,000 hours of flight. The mortality of HEMS personnel has been estimated at 75 per 100,000 people per year, 16 times higher than the overall occupational mortality. 85.5% of the claims were due to human error, not only by the pilot (76%) but also to inadequate maintenance, coordination or management of the programme. HEMS programmes have the worst air traffic accident record since 1998, with 1 in 4 HEMS suffering an accident every 15 years of service, of which one third will be fatal. Factors include 24/7 flight without warning or flight plan, poor weather forecasting, unprepared grounding points, need to make critical decisions on the fly, overuse of the helicopter. Night flight triples mortality, flight in adverse weather conditions multiplies it by 8 and the existence of fire after impact multiplies it by 16.[254]

19

HAEMORRHAGE, SHOCK AND SUSPENSION TRAUMA

Shock is an alteration of the circulation that reduces the arrival of blood in the tissues, causing a hypoxic cell injury, which if prolonged may be irreversible.

In mountain accidents, there is mainly hypovolemic shock secondary to haemorrhage, and sometimes neurogenic shock due to spinal cord injury.

HYPOVOLAEMIC SHOCK (HAEMORRHAGIC)

Cause

Hypovolaemia due to haemorrhage is the most common cause of shock in the polytraumatised patient. Hypovolemic shock usually occurs when the circulating blood volume is reduced by 15-25%; in any event, a loss of 1.5 litres of blood almost always causes shock.

In a polytraumatism, the bleeding that causes shock usually occurs in the thorax (e.g. haemothorax), abdomen (e.g. visceral injury), pelvis (e.g. retroperitoneal haemorrhage due to complete fracture of the pelvis), long bones (e.g. complete fracture of the femur) or in the form of visible external haemorrhage.

In addition to the bleeding itself, the injured tissues are oedematous. A quarter of the oedema comes from blood plasma, which further reduces intravascular volume. For example, a complete fracture of the femur produces 1.5-2 litres of oedema, of which 500 cm³ come from blood plasma. This loss of blood volume must be replaced by fluid perfusion.

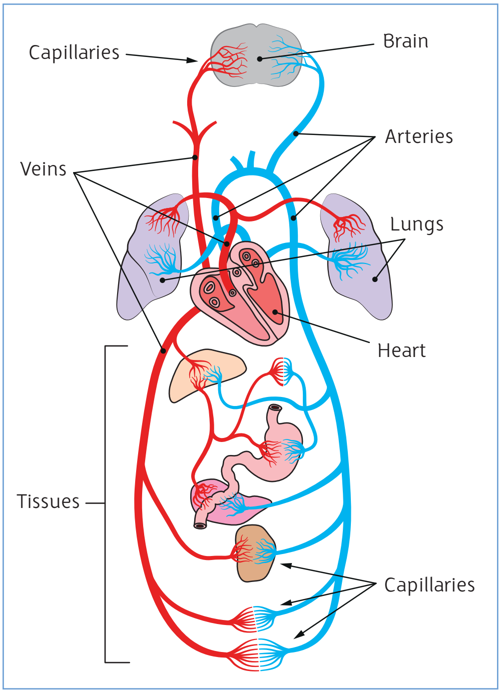


Figure 19.1. Circulation.

Table.19.1. Approximate volume of blood loss by type of injury (SEMICYUC Advanced Support Manual on Polytrauma)

Lesion	Volume of blood lost
Complete rib fractures	100 – 200 cm³
Complete humerus fractures	500 – 1,500 cm³
Complete forearm fracture	200 – 500 cm³
Complete tibia fracture	500 – 1,500 cm³
Complete femur fractures	1,000 – 2,500 cm³
Complete pelvic fracture with pelvic ring opening	1,000 – 5,000 cm³
Intra-abdominal bleeding	2,000 - 4,000 cm³ (2,000 cm³ for the liver and another 2,000 cm³ for the spleen)
Hemothorax	1,000 cm³ in each hemothorax
Spinal column	1,000 – 5,000 cm³

Initial assessment

The initial assessment should be made at the scene of the accident, following the A-B-C-D-E method as in any trauma.

In the initial examination of blood circulation **(C)**, signs of shock are usually found: [255]

- Tachycardia: this is one of the earliest signs to appear. In the event of a traumatic event, if the heart rate is above 100 bpm (child >120 bpm, preschool >140 bpm), it is assumed that the patient is in shock until proven otherwise. The heart pumps at a faster rate so that a smaller amount of circulating blood travels faster, in order to make a smaller volume of blood carry the necessary oxygen. This compensation mechanism is effective until 10-15% of blood volume is lost. The well-trained sportsperson is usually bradycardic and his or her heart rate may not reflect the blood loss. Tachycardia is a predictor of mortality in polytraumatic patients with hypotension (OR + 14.5. OR – 0.2).
- Systolic blood pressure below 100 mmHg in the context of a severely injured patient. The decrease in blood pressure does not occur until the patient has lost 30-40% of blood volume. In patients with normal hypotension, a reduction of 20-30 mmHg compared to their usual level is considered to be hypotension. In patients in hypovolemic shock, there is a correlation between systolic blood pressure greater than 60 mmHg and the existence of carotid OR + 1.2. OR – 0.2), femoral (OR + 2.9. OR – 0.1) and radial (OR + 4.7. OR – 0.5) pulses.
- Prolonged capillary refill: after pressing the nail with your finger, the capillaries are refilled with blood and the pink colour is restored in less than 2 seconds. A capillary refill that takes longer than 2 seconds indicates that the blood is not reaching the tissues properly. This test is not assessable in hypothermic cases
- Cold, pale, sweaty skin due to peripheral vasoconstriction caused by increased catecholamines so that most of the blood supplies oxygen to the central organs instead of oxygenating the periphery of the body.
- Pulse is fast and weak.
- Impaired consciousness.
- A pulse pressure (systolic – diastolic blood pressure) of less than 20 mmHg suggests that there is a significant loss of blood.

Table 19.2. Signs and symptoms of hypovolemia and anemia[256]

	CP+	CP–
Hypovolemia		
Heart rate increase by 30 BPM	1.7	0.8
Systolic BP drop by 20 mmHg	1.5	0.9
Underarm dryness	2.8	0.6
Dry mouth and nose mucous membranes	3.1	0.3
Dry tongue	2.1	0.6
Furrows in the tongue	2	0.3
Dry eyes	3.4	0.5
Confusion	10	0.5
Weakness of limbs	2.3	0.7
Abnormal skin turgor	3.5	0.3
Speech difficulties	3.1	0.5
Capillary filling >2 sec.	6.9	0.7
Anaemia		
Pallor in some locations	4	0.5
Facial paleness	3.8	0.6
Nail bed pallor	3.9	0.5
Palmar paleness	5.6	0.4
Conjunctival rim pallor	16.7	-

As a general rule, in the mountains it is assumed that any polytraumatised person who is tachycardic and cold is in shock until proven otherwise.

Blood volume represents 7% of the ideal body weight in the adult and 8-9% of the body weight in the child (for example, a 70 kg adult has about 5 litres of blood volume).

Table 19.3. Classification of hypovolemic shock by percentage of blood volume loss (American College of Surgeons)

	Class I	Class II	Class III	Class IV
Losses in mL	Up to 750	750-1,500	1,500-2,000	>2,000
% loss of blood volume	Up to 15%	15-30%	30-40%	>40%
Cardiac frequency	<100	>100	>120	>140
Blood pressure	Normal	Normal	↓	↓↓
Capillary refill	<2 sec	2-2.5 sec	>3 sec	>4 sec
Respiratory rate	14-20	20-30	30-40	>35

If there are signs suggestive of a hypovolemic shock (tachycardia), the five places where bleeding may be severe enough to produce shock are explored and initial treatment is performed **(A)**:[203]

- Thorax (e.g. hemothorax). If this is the cause, it may have been detected when checking the breath **(B)**.
- Abdomen (e.g. visceral injury).
- Pelvis (e.g. retroperitoneal haemorrhage due to a complete fracture of the pelvis). The clinical examination has a sensitivity of 44% and specificity of 99%. If the systolic BP is greater than 90 mmHg you can excluded that the complete fracture of the pelvis is producing clinically relevant bleeding (100% negative predictive value).[203]
- Long bones (e.g. complete femur fracture).
- Visible external bleeding.

Treatment[203, 257]

A-B-C-D-E method (see Chapter 15)

Control of haemorrhage

- External haemorrhage:
  - Local compression on the bleeding site with the help of dressings. When the dressings become soaked, new ones should be placed on top without removing the already soaked ones, as doing so will make it difficult for a clot to form.
  - If necessary, a compressive bandage may be applied to the bleeding wound. Venous bleeding may subside after 5 minutes of manual compression. This would be the initial technique of choice, but it may be impractical if it is to be done over a long period of time, also the application of compressive bandages with gauze dressings is not always effective in stopping bleeding due to capillarity **(B)**.
  - Arterial compression at a point above the bleeding wound – not used because collateral circulation occurs and bleeding resumes in 60 seconds in the upper extremities and 30 seconds in the lower extremities.
  - Tourniquet 5-7 cm above the wound: used in massive, life-threatening bleeding or limb amputation. Survival exceeds 90-96% if placed before the patient is in shock and 4-10% if placed when the patient is already in shock. Its placement for more than 2 hours can have consequences, especially muscle ischemia and nerve compression paralysis **(B)**.[221]
  - Haemostatic dressings. May be useful in massive haemorrhaging **(B)**.[258]
- Suspected bleeding from pelvic trauma (falling from a height with pelvic pain):
  - Bleeding associated with complete pelvic fractures may occur directly from the fractured bone, from the pre-sacral venous plexus or from the iliac vessels.
  - If the shock is suspected to be caused by an unstable complete fracture of the pelvis (pain), stabilise and reduce pelvic volume **(B)** to try to minimise bleeding. In the mountains, a pelvic sling is usually

used.[224] The use of pelvic slings is effective in restoring normal bone anatomy and may reduce the bleeding volume, but they may also cause local tissue damage. The results of studies on the benefit of their use are heterogeneous, and more studies are needed to determine their efficacy in reducing mortality or bleeding in complete unstable pelvic fractures.[225]

  - Another method would be to tie the pelvis with a sheet, bearing in mind that the sheet should also cover the greater trochanter of the femur and not just the ridges of the pelvis. If necessary, a fixing system can be improvised.
- Suspected haemorrhage due to complete fracture of long bones: immobilisation may minimise haemorrhage.

Oxygen administration if possible to get oxygen saturation 94-98%

There is no evidence that elevating the legs of the injured person can promote the return of blood from the limbs to the vital organs (brain, heart, etc.) and improve the state of shock, although it produces a transitory improvement in vital signs (<7 minutes).[175, 198]

Control of hypothermia

Fluid therapy[259]

Prehospital fluid therapy may increase mortality by increased perfusion, which may result in increased bleeding, haemodilution of clotting factors, clot destruction, hypothermia and delayed hospital evacuation.[260] The current recommendations are:[261]

- Patients with severe head injury and shock: saline solution to maintain systolic blood pressure >90 mmHg (at least 100 mmHg).
- Other trauma patients, including those with penetrating wounds to the chest and abdomen: saline solution to maintain systolic blood pressure of 90 mmHg.

In the out-of-hospital setting, as a general rule, serum perfusion is not recommended in patients with palpable radial pulse, whereas in patients with no palpable radial pulse, the administration of a bolus of physiological serum (maximum 250 cm^3) is recommended until the radial pulse is palpable. Serum therapy should not delay the transfer to hospital **(C)**.[262]

If the peripheral veins are collapsed and a peripheral catheterisation is not achieved within 90 seconds (3 attempts), perform the perfusion via the intraosseous route.

Liquids should be perfused at a temperature of about 37-40 °C to avoid producing or worsening hypothermia.

Although there is no difference in survival if isotonic or hypertonic saline is used,[263-265] in mountain areas the International Commission for Alpine Rescue IKAR approves the method of replenishment with small volumes due to:

- Low weight and volume for easy transport.
- Keeps warm more easily.
- It can be administered quickly.
- It is effective in a few minutes.

It may be indicated in traumatic, hypovolemic and haemorrhagic shock, especially in combination with severe head trauma.

Procedure

- Channelling of one (better two) large gauge venous line(s) (14G, 16G). It is recommended not to exceed 3 attempts of peripheral channelization in 90 seconds, if during this time it is not possible to channel a line, it is recommended to perform an intraosseous puncture.
- Administration of hot hypertonic solution in bolus (3-5-10 minutes). Maximum adult Dose is 4 mL/kg by weight. The administration of 7.5% hypertonic saline is recommended (preparation: 180 mL of physiological saline plus 7 ampoules of 10 mL of 20% ClNa).
- Assess its effects on blood pressure, heart rate and peripheral circulation
- The effect lasts about 30 minutes, so that if necessary a perfusion of isotonic crystalloid solutions (physiological serum) can be continued with.

In case of not using the replenishment system with small volumes, the classic system consists of the perfusion of physiological serum **(B)**.[203] Initial adult dose recommended by the international ATLS (Advanced Trauma Life Support) working group266 is 1,000 cm^3 (30 mL/kg) and can vary from 500-2,000 cm^3 to find palpable radial pulse. In children, it is 20 cm^3 per kg of weight. This dose should be perfused at the maximum possible rate (10-15 minutes). A minimum urine output of 0.5 mL/kg/hour (children: 1 mL/kg/h) should be maintained **(A)**.

There is no evidence that the use of colloids provides advantages, with no differences observed in mortality.[267]

It is not recommended to place the patient in the Trendelenburg position as it has no benefit in terms of improving haemodynamic status.[268]

Inotropics and other drugs

There is no evidence that vasopressor drugs are useful in the treatment of hypovolemic shock, and they may increase mortality.[269, 270]

They may be useful in patients with associated traumatic brain injury in whom blood pressure is not maintained above 90 mmHg despite fluid therapy, although more studies are needed.[271]

If there is a symptomatic bradycardia: atropine 0.5 mL, which can be repeated up to 1.5 mL. If it persists, perfuse isoproterenol until a heart rate of 60 bpm is reached.

NEUROGENIC SHOCK

Injuries to the brain stem or spinal cord above D5 can lead to loss of vascular control and vasodilatation, resulting in an imbalance between the container (vessels) and the contents (blood), since, although there has been no loss of blood volume, dilation of the vessels occurs as if there were and shock occurs. Isolated head trauma does not cause this type of shock.

Signs and symptoms

Low blood pressure without tachycardia (including bradycardia) or peripheral vasoconstriction.

Treatment

Just as in hypovolemic shock.

If there is symptomatic bradycardia: atropine 0.5 mL, which can be repeated up to 1.5 mL. If it persists, perfuse isoproterenol until it reaches a heart rate of 60 bpm.

SUSPENSION TRAUMA (HARNESS HANG SYNDROME)[272 273]

When immobility in an inert position (due to exhaustion or unconsciousness) is added to suspension in a sling, muscle pumping of the blood decreases or disappears, especially in the lower extremities. The blood is sequestered in the venous system of these limbs, reducing the venous return to the heart. All of this leads to a decrease in cardiac output, arterial hypotension, a decrease in cerebral perfusion, loss of consciousness and death. Death can occur in 10 minutes.

In some cases, death is due to acute overload of the right ventricle by massive return of blood accumulated in the lower extremities, when the injured person is placed in a horizontal position. In other cases, death has occurred between 1 and 11 days later, due to multi-organ failure and acute renal failure secondary to crushing syndrome: it occurs after the release of substances produced by the muscular necrosis that had occurred when the legs were compressed by the large oedema. Among the substances that emerge after decompression of the extremities are; potassium, producing hyperkalaemia that can lead to severe arrhythmias and death; and thromboplastin, which can lead to death by disseminated intravascular coagulation (DIC).

Prevention

- Use a comfortable harness.
- Support your feet to stay suspended for as little time as possible.
- If suspended, raise and move your legs.

Treatment

- Start the rescue as quickly as possible (<3 min).
- A-B-C-D-E approach .

- If they have hypotension during transport to hospital, it is better to administer vasoactive drugs than mass fluid replacement.
- Blood glucose control, especially if the cause of the harness syndrome has been exhaustion.
- Assess concomitant injuries.
- Transfer to hospital. If they have been suspended for more than 2 hours, transfer to a dialysis facility.
- In the hospital, the perfusion of saline solution with bicarbonate will be evaluated to maintain a urine output of 200-300 mL/hour at pH >7, in order to prevent an acute renal failure. Once a correct intravascular volume is reached, mannitol may be initiated. Monitor constants and possible arrhythmias.

OTHER TYPES OF SHOCK

Other types of non-haemorrhagic shock besides neurogenic and harness syndrome include cardiogenic shock (from myocardial contusion), obstructive shock (from tension pneumothorax or cardiac tamponade), septic shock (usually late-stage), and spinal shock, which is recognised as producing large flaccidity and areflexia.

20 CRANIOENCEPHALIC AND SPINAL TRAUMA

THE NERVOUS SYSTEM

The nervous system is made up from neurons that are very sensitive to hypoxia, and are the first to deteriorate and die if oxygen supply ceases. The nervous system is classified into central nervous system and peripheral nervous system. The central nervous system comprises the brain (encephalus) and the spinal cord.

Brain (encephalus)

Inside the skull, we find:

- The brain, which performs the higher functions and control of voluntary movements, and interprets the information it receives from the senses.
- The cerebellum, which controls movement coordination and balance.
- The brain stem, where the vital centres (breathing, temperature, etc.) are located.

Spinal cord

It is made up of nerve bundles that pass through the canal in the posterior region of the spine. It has a dual function:

- It is the axis of transmission that transmits information collected in the periphery by the sense organs to the brain, and transmits the motor orders of the brain to the periphery so that the muscles can be activated.
- It is a reflex centre that controls acts without brain involvement, and produces a response directly from the spinal cord.

CRANIOENCEPHALIC TRAUMA

Trauma is the leading cause of death and disability in the under 40 population. It is responsible for 75% of trauma deaths. Of all patients admitted for traumatic brain injury 10% are in severe condition (Glasgow scale ≤ 8).

Traumatic brain injury is defined as a structural injury and/or physiological impairment of the brain function caused by an external force and is characterised by the onset or worsening of at least one of the following signs or symptoms, to some degree, and for a period following the trauma:

- Decreased or loss of consciousness.
- Amnesia for events occurring immediately before or after the trauma.
- Alteration of mental state (confusion, disorientation, bradypsychism, etc.).
- Neurological deficit (weakness, balance disorder, vision changes, paralysis, sensory deficit, aphasia).
- Intracranial injury.

Traumatic brain injury involves two phases: the first phase, which occurs during impact, results from the deformation of the white and grey matter of the brain, causing the rupture of cell membranes and the release of intracellular contents. The second phase occurs hours or days after the initial trauma and is caused by cerebral oedema, the formation of free radicals and the release of inflammatory mediators, which can exacerbate the initial injury and possible post-traumatic consequences through cell damage or death. Traumatic brain injuries may occur at the time of the trauma or after it. Therefore, treatment should be aimed at providing the injured brain with a suitable environment that allows maximum recovery from primary lesions and prevents or treats secondary lesions.

In the first phase, it should be noted that a contusion on the head can rupture some of the blood vessels surrounding the brain; blood from these vessels remains in the small space between the skull and the brain and causes a clot, compressing the brain. Bleeding or oedema compresses the brain within the skull and often results in a more severe injury than the original injury. This haemorrhage or tumefaction, which would not be of great importance elsewhere in the body, if it appears inside the skull, leads to an increase in intracranial pressure that can compromise cerebral blood flow and lead to a more serious injury than the original one, or even death if the hematoma is not drained in a neurosurgery department.

The chance of having a subdural hematoma that causes intracranial hypertension is 1 in 4 if there is complete fracture and disorientation, 1 in 30 if there is complete fracture without disorientation, and 1 in 100 if there is disorientation without complete fracture.[274] The haemorrhage can also be epidural and intraparenchymal.

Initial assessment

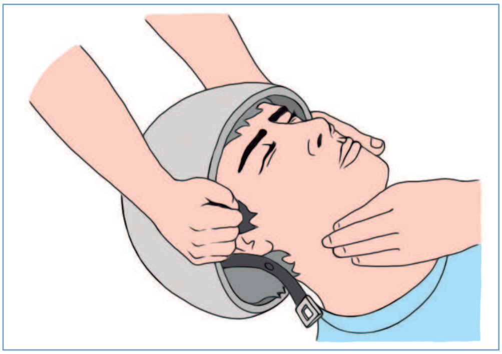


Figure 20.1. Helmet removal.

The initial assessment is performed following the A-B-C-D-E method as in any trauma.

The initial neurological examination **(D)** will include:

- Assessment of the level of consciousness using the Glasgow scale or the AVPU scale (Alert, Verbal, Pain, Unresponsive) which is easier to remember and correlates with the Glasgow scale. The Glasgow scale can be useful for monitoring the progress of the injured person, especially for assessing clinical worsening. The motor component (motor response) may be a better predictor of outcomes.
- Pupillary examination (size, symmetry, and photomotor reflex).
- The detection of signs and symptoms of structural injury or intracranial hypertension: pupillary asymmetry >1mm (OR + 9.OR – 0.6), absence of photomotor reflex (OR + 3.6. OR – 0.2), vomiting and neurological focality.[256]
- If the patient is conscious, the existence of post-traumatic amnesia is assessed. Duration of post-traumatic amnesia greater than 4 hours is a risk factor for intracranial injury.[275]
- Duration of loss of consciousness.
- Assessment of motor or sensory deficits.
- Remember that hypoxia produces agitation, hypercapnia and drowsiness.
- Head trauma is often associated with cervical spine trauma.

During the secondary exploration, inspect the head for external injuries and palpate for complete fractures, and if the trauma does not involve the airway, treat maxillofacial injuries when the injured person is stable.

Although no deformity or instability of the skull bones can be seen, complete fracture of the skull base is suspected if blood comes out of an ear or nose, or if there is a bruise behind an ear or around an eye.

Risk factors for intracerebral injury (odds ratio: 83%; 95% CI: 78.8-87.1)[276]

- Age (OR 1.03; 95% CI: 1.02-1.04).
- Concussion recovered (OR 3.6, 95% CI: 1.68 to 7.63).
- Post-traumatic amnesia (OR 2.58; 95% CI 1.58 to 4.19).
- Repeat (OR 2.21; 95% CI: 1.02 to 4.78).
- Otorrhagia (OR 41.75; 95% CI: 3.94-442.54).
- Anisocoria (OR 14.10; 95% CI: 2.41-82.46).
- Glasgow scale 14 (OR 2.82; 95% CI: 1.55-5.15).
- Glasgow scale 13 (OR 4.39; 95% CI: 2.35 to 8.18).

Take into account hypoglycaemia, alcohol and toxics as non-traumatic causes of impaired consciousness.

During neurological reassessment, pay attention to signs of neurological impairment.

Early signs of deterioration

- Confusion.
- Agitation.
- Drowsiness.
- Vomiting.
- Severe headache.

Late signs of deterioration

- A drop in the Glasgow scale score of 2 points or more.
- Pupil dilatation.
- Focal neurological deficit.
- Seizures.
- Bradycardia and hypertension.

Table 20.1. Correlation between the Glasgow scale and the AVPU scale[227]

AVPU Scale	Glasgow Scale
Alertness	14-15
Verbal response	9-14
Pain response	4-10
No response	3-5

Glasgow Scale	
Eye opening	
Keeps eyes open	
Never	1
Only to painful stimuli	2
Eye opening to speech	3
Spontaneously	4
Verbal response	
No answer	1
Incomprehensible sounds	2
Inarticulate speech, uses inappropriate words	3
Confused language, disoriented	4
Speaking and oriented	5
Motor response	
No answer	1
Extensor posturing. Decerebrate response	2
Flexor posturing. Decorticate response	3
Flexion- Withdrawal from pain	4
Localises to pain	5
Voluntary response	6

Total score:
3-15 (considered severe if less than 9 for at least 6 hours after neurological impairment).

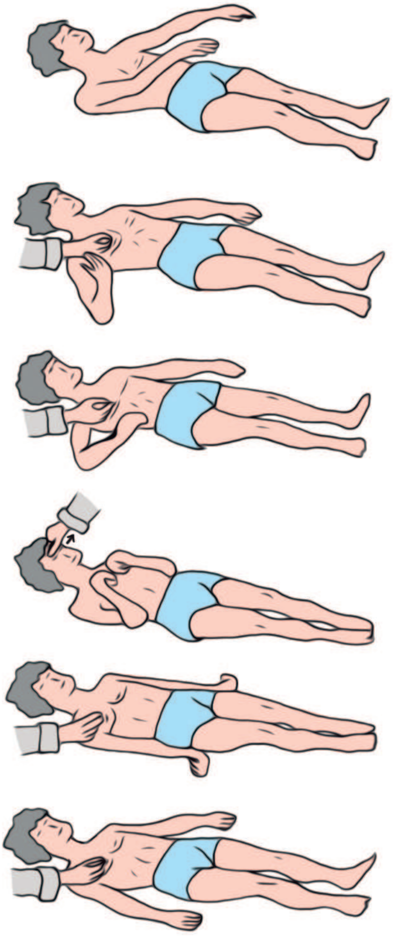


Figure 20.2. Glasgow scale.

Classification

According to the Glasgow scale, head injuries are classified as mild, moderate or severe.

Table 20.2. NSW Institute of Trauma and Injury Treatment[275]

	Mild	Moderate	Severe
Glasgow Scale	14-15	9-13	3-8
CT with alterations (%)	5-15	30-50	60-90
Neurosurgical intervention (%)	1-3	5-30	30-50
Mortality (%)	<1	10-15	30-50
Return to normal life in 6 months (%)	>90	20-90	<20
Frequency (%)	80	10	10

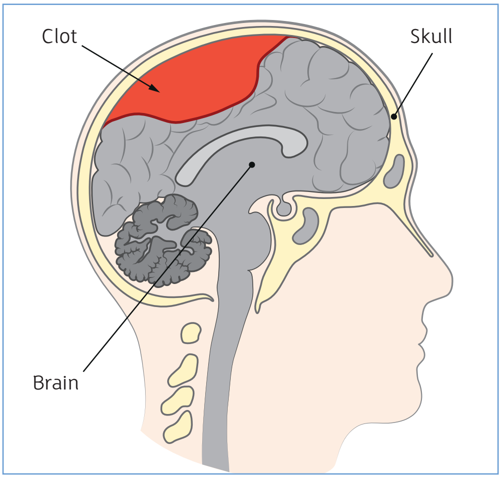


Figure 20.4. Intracranial bleeding.

Prevention

The skull is between 4 and 7 mm thick and is not prepared to suffer violent impacts, therefore the best prevention against head injury is the use of helmets in climbing, mountain biking and skiing, as in recent years there has been a worrying increase in serious head injuries on alpine ski slopes. At a speed of 15 km/h, a helmet reduces the energy applied to the head by 90%. In addition, helmet use reduces the injury severity index from 18 to 3.8. Overall, a helmet reduces the risk of severe head injury in skiing by 35% in adults and 60% in children.[277-281] Although helmet use slightly decreases hearing of sounds,[282] it does not decrease vision or reaction time to peripheral stimuli[283] so there is no evidence that it may increase the risk of an accident.

SALOMON
gusta la nieve

Figure 20.3. Broken helmet.

Immediate treatment[275, 284-286]

Minor cranial trauma (Glasgow 14-15) (A)

Treatment

- A-B-C-D-E method.
- Clinical observation to detect intracranial injury risk factors considering the possibility of an epidural hematoma; these accident victims may have a lucid interval and then worsen rapidly.
- CT or MRI scan if there are risk factors for intracranial injury.
- If after 4 hours of observation no risk factors for intracranial injury are observed, or if the CT scan is normal discharge them home with recommendations on warning indicators and advice to go to their doctor if the improvement is not complete by 48 hours.
- If the CT is abnormal, there are risk factors for intracranial injury; pay special attention to the elderly, patients treated with anticoagulants, or with psychosocial problems, and have them admitted for observation

and/or consultation in the neurosurgery department.

Recommendations to be followed by the injured who have suffered a mild head injury within 24 hours of discharge

- Try to rest, avoiding bright lights and loud noises.
- Take pain relievers prescribed for headaches.
- Eat light foods and don't force yourself to eat if you don't have an appetite.
- Apply snow or ice wrapped in a cloth or towel to the trauma area.
- The wounded can sleep, but must be awakened every three hours.
- Be in the company of someone who can advise of the warning signs.

Moderate cranial trauma (Glasgow 9-13) (B)

Treatment

- A-B-C-D-E method.
- Consider intubation if A or B deteriorated, or for ease of handling if the patient is restless: during intubation, consideration should be given to the possibility of concomitant cervical injury and stabilisation of the cervical spine. The practice of intubation with indirect methods (e.g. Fastrach) is recommended to minimise the risk of aggravation of a possible cervical injury and to minimise the risk of increased intracranial pressure (ICP).[287]
- Avoid hyperventilation or hypoventilation.
- The head should be maintained in a neutral position (neither flexion nor extension), aligned with the trunk to avoid compression of the jugular vein and elevated 30º above the horizontal plane.
- Prevent aggravation of brain injury by avoiding hypoxemia (SpO_2 <90%) and hypotension (systolic BP <90 mmHg). To treat hypovolemic shock, maintain blood volume and plasma osmolarity, use a physiological saline solution (0.9% ClNa). Hypotonic solutions or solutions that produce hyperglycaemia (5% glucosate, gluco-saline, Ringer-lactate) may aggravate brain injury, so avoid their administration **(A)**.
- Avoid hypoglycaemia and hyperglycaemia above 200 mg/dL, as it decreases the oxidative metabolism of glucose and cellular pH, causing a longer delay in starting cerebral perfusion when faced with ischaemia.
- Early CT or MRI scan to detect any injury that requires neurosurgery.
- Clinical observation.
- Consult neurosurgery if it worsens or if CT/MRI are altered.
- Repeat CT/MRI after 24 hours if there is no improvement, or if the initial CT/MRI has changed.
- Periodically assess post-traumatic amnesia.
- Assess the need for anticonvulsants (phenytoin 20 mg/kg IV at rate of infusion <50 mg/min; 1000 mg phenytoin in 150 mL saline solution to be passed in 1 h) to prevent post-traumatic convulsions **(B)** if:
  - CT scan with extradural, subdural, or intracerebral hematoma.
  - Complete skull fracture with bone depression.
  - Early post-traumatic seizure (especially if focal or prolonged).
  - Severe injury (Glasgow Scale with low score, prolonged coma, prolonged post-traumatic amnesia).
  - Suspicion of penetrating injury.
- If the CT or MRI show mass effect consider:
  - Deep sedoanalgesia and intubation if Glasgow scale <9.
  - Deep muscle relaxation if you intubate.
  - Hyperosmolar treatment with hypertonic saline or administration of a 20% mannitol bolus (1 g/kg) in 5 minutes. It is contraindicated in hypotensive accidents. It may be the first choice in non-intubated patients with Glasgow worsening (e.g. Glasgow descent from 15 to 12). The available evidence suggests that hypertonic saline solutions may be more effective than mannitol in reducing intracranial pressure in patients with traumatic brain injury and should therefore be considered as first line treatment.[288]

  - Moderate momentary hyperventilation of short duration to obtain a $PaCO_2$ of 30-35 mmHg that produces a cerebral vasoconstriction diminishing the intracranial pressure. If hyperventilation is more intense and prolonged, it can cause cerebral ischemia. Avoid routine hyperventilation, as it does not prevent endocranial hypertension and can lead to cerebral ischemia **(B)**. Manual ventilation by reservoir balloon insufflation can lead to hyperventilation.
  - Assess the need for anticonvulsants to prevent post-traumatic seizures.
  - Surgical decompression if the transfer to the neurosurgery centre takes longer than 2 hours.
- Transfer to hospital with neurosurgery facilities.

Severe head injury (Glasgow 3-8) (A)

Treatment

- Just as with moderate head trauma.
- Early intubation.

Objectives

- PaO_2 >80 mmHg.
- SpO_2 >95%.
- $PaCO_2$ 35-40 mmHg.
- Systolic BP >90 mmHg.
- Elevation of the head 30° above the horizontal plane.

Indicators of poor prognosis

- Glasgow scale with low score, especially on the motor component.
- Age >60.
- Absence of pupillary reflexes after resuscitation.
- Hypotension (systolic BP < 90 mmHg).
- Hypoxemia (SpO_2 < 90%).

Risk factors for brain injury: indication for CT in head trauma (CHIP prediction rules 2007)[289]

Presence of one major criterium

- Pedestrian or cyclist.
- The person has been ejected from the vehicle.
- Presence of vomiting.
- Post-traumatic amnesia ≥ 4 h.
- Clinical signs suggestive of complete skull fracture: palpable discontinuity in the skull, cerebrospinal fluid leakage, "raccoon eyes", bruising or bleeding from the ear.
- Glasgow <15 at 2 hours after the trauma.
- Deterioration of the Glasgow scale ≥ 2 points 1 hour after the trauma.
- Use of anticoagulants.
- Post-traumatic apoplexy.
- Age ≥ 60.

Presence of at least two minor criteria

- Fall from any height.
- Persistent anterograde amnesia, any recent memory deficit.
- Post-traumatic amnesia of 2-4 h.
- Cranial contusion.
- Neurological deficit.
- Loss of consciousness.
- Deterioration of the Glasgow scale by 1 point 1 hour after the trauma.
- Age between 40 and 60.

Use of neurological damage biomarkers

Nearly 100 biomarkers have been studied. Neuronal specific enolase greater than 15 ng/mL correlates with intracranial lesions in the CT scan; L1 carboxy-terminus ubiquitin hydrolase has a 100% negative predictive value and is detectable in the first hour after trauma.[290-292]

SPINAL TRAUMA

The severity of vertebral lesions is determined by the possible association of spinal cord injury. Between 5 and 10% of unconscious patients admitted to an emergency department after an accident have a complete cervical spine fracture; 30-50% of secondary cervical spine displacements result from poor recognition of a severe sprain.

Initial assessment

A-B-C-D-E method.

A: cervical spine control from the beginning.

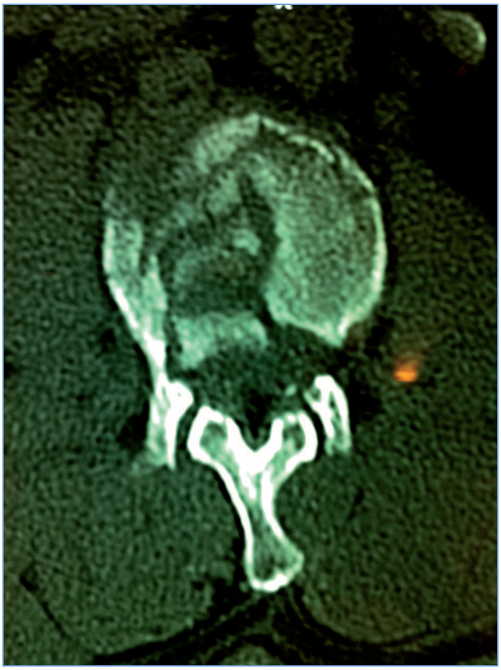


Figure 20.5. Fractured spine from contusion.

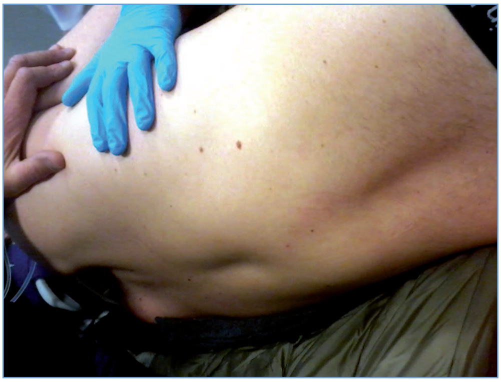


Figure 20.6. Hematoma in the spinal area.

B-C.

D-E: explore the nape of the neck for crackling or pain, palpate the spinous processes of the cervical vertebrae for complete fracture. Assess motor and/or sensory deficits: tingling, weakness or difficulty in moving the legs. Loss of anal sphincter tone with faecal incontinence and priapism suggest spinal shock.

About 2% of trauma patients have a spinal injury, a possibility that increases in case of injury above the clavicle or Glasgow <8. Therefore, it is recommended to act as though a spinal cord injury is suspected, especially in unconscious patients **(A)**.[203]

The medical history is very orientative **(B)**[203] clinical examination is unreliable for detecting complete cervical fracture (46% sensitivity and 94% specificity) and lateral radiography up to C7 detects 85-90% of complete fractures. Therefore, CT or MRI scans are the complementary scans of choice.

Spinal injury is suspected when:

- The victim is over 65 years of age.
- There is a bicycle or motor vehicle accident.
- Fall from greater than standing height (1 m or 5 steps).
- Tingling in extremities.
- Neck or back pain or tenderness.
- Weakness or tenderness disorder of the torso or upper limbs.
- Low level of consciousness or intoxication.
- Have other painful injuries.
- Child over 2 years old with Glasgow <14.

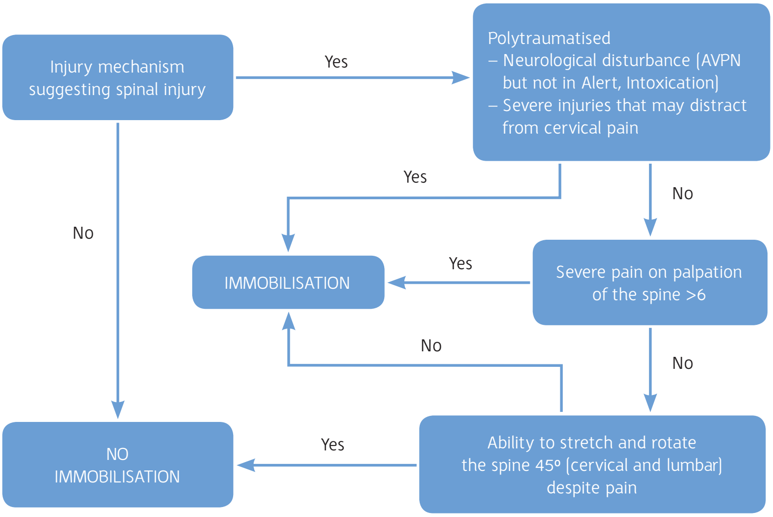
If the above risk factors are not present but the patient is unable to actively rotate his or her neck 45° from left to right, also perform imaging tests (CT/MRI).[293]

In the event of a closed cervical spine trauma, an imaging study can only be stopped if it meets ALL 5 NEXUS criteria:[294, 295]

- Absence of pain on palpation of the spinous processes.
- Absence of focal neurological deficit.
- Glasgow 15.
- Absence of intoxication.
- Absence of another painful lesion that may mask cervical pain.

The Wilderness Medical Society has published recommendations based on scientific evidence, which assesses the risk-benefit of vertebral immobilisation in areas of difficult access and where there is potential danger. The algorithm in these recommendations is “less strict” than the NEXUS or Canadian C-Spine Rules criteria for cervical spine x-rays. This algorithm is useful for detecting accidents in which immobilisation is necessary to avoid

Figure 20.7. Spine immobilisation specifications **(A)**.[229]


Injury mechanism suggesting spinal injury
Yes
Polytraumatised
– Neurological disturbance (AVPN but not in Alert, Intoxication)
– Severe injuries that may distract from cervical pain
Yes
No
No
IMMOBILISATION
Yes
Severe pain on palpation of the spine >6
No
No
NO IMMOBILISATION
Yes
Ability to stretch and rotate the spine 45º (cervical and lumbar) despite pain

worsening the neurological situation (complete unstable fracture with or without neurological compromise and clinically unstable patients). Accidents that do not require immobilisation according to this algorithm should be re-evaluated in the accident and emergency department to perform imaging studies.[229]

Treatment

A-B-C-D-E method

Initial movement and evacuation

Neutral alignment of the spine by gentle or moderate traction is recommended and maintained during evacuation unless resistance, increased pain or the onset or worsening of a neurological deficit is encountered during attempted traction. If it is not possible to scan the cervical spine prior to evacuation, the casualty is allowed to leave at will if the patient is reliably alert. Otherwise, immobilise with a FERNO KED type column immobiliser and move them into a sitting position on a spinal board or vacuum mattress **(B)**.[229]

Immobilisation for transfer

If spinal cord injury is suspected, attempts are made to keep the cervical spine in a neutral position at the midline. To do this, the head is held firmly by the sides (mastoid and occipital process), avoiding any traction or sudden movement. Routine application of a cervical collar or bilateral sandbags is not normally recommended because the benefits do not outweigh the potential adverse effects (especially endocranial hypertension and airway involvement) **(B)**.[198]

If conscious, the injury mechanism does not suggest cervical injury, there is no cervical pain or any pain that may mask the cervical pain, nor intoxication that decreases consciousness, and the patient can move the neck spontaneously, there is no need for cervical immobilisation or further exploration. In other cases, cervical immobilisation can be assessed, always taking into account its possible adverse effects.

The patient is then moved, if possible on a scoop stretcher, to the vacuum mattress, which is the system of choice. The neutral position of the head must be maintained during transport with the vacuum mattress. A Kendrick's spinal splint (Ferno KED) can be used **(B)**.[229, 287, 296, 297, 298]

If there is a penetrating wound, the patient will not be immobilised.

If the helmet is removed, keep the cervical traction in place.

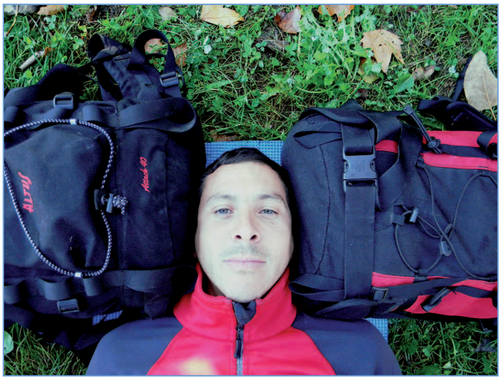


Figure 20.8. Immobilisation of the cervical spine with a backpack.

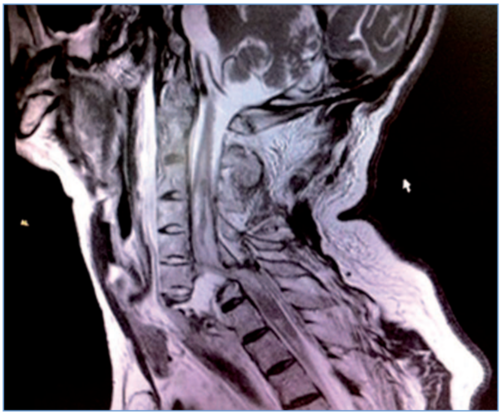


Figure 20.9. Complete cervical fracture.

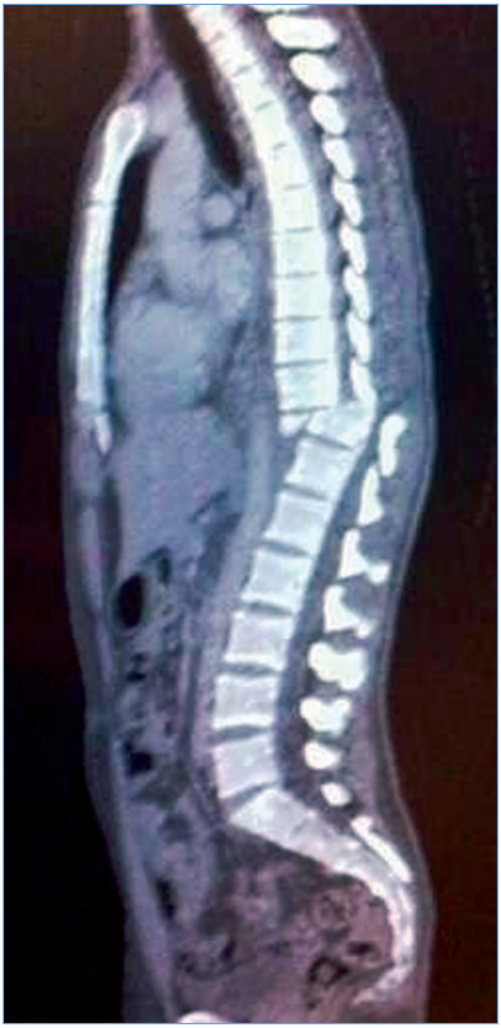


Figure 20.10. Spinal cord injury.

Traumatic spinal cord injury

Signs for concern

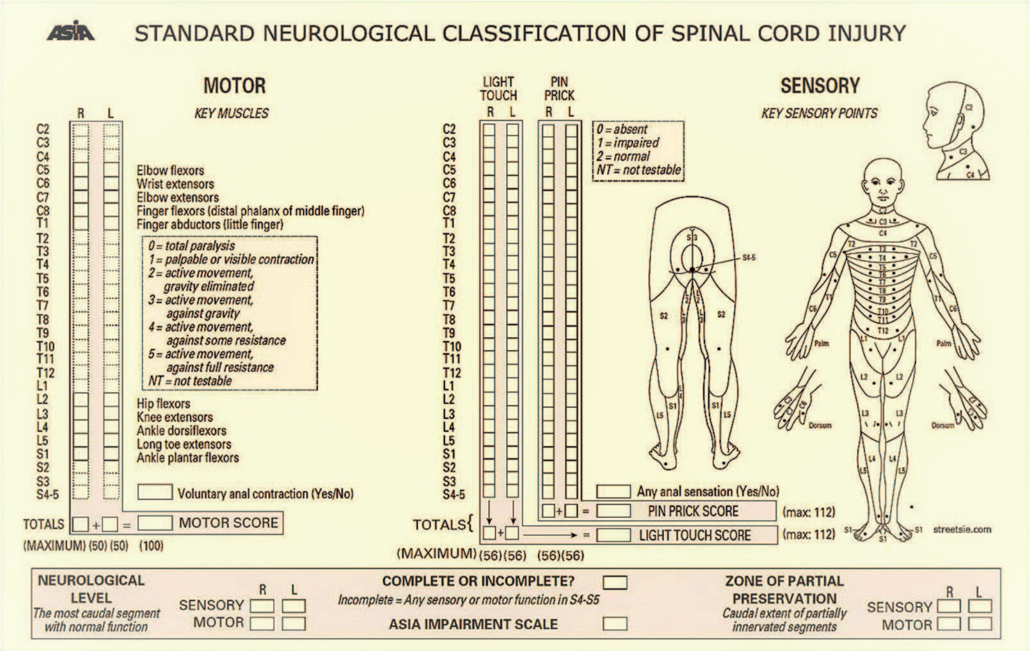
- Motor signs: weakness or paralysis of the limbs and muscles of the trunk.
- Sensitive signs: alteration or lack of sensitivity in the trunks and extremities.
- External signs: abrasions, lacerations or deformities of the head, neck and spine.
- Pain: painful tenderness to the palpation of the spine or neck.

Medical treatment

Methylprednisolone is not recommended because of its doubtful efficacy and increased risk of infection **(C)**.[299, 300] GM-1 ganglioside is also not recommended.[301, 302]

CT or MRI of the spine is performed in the hospital.

Neurogenic shock may be associated with vasodilatation leading to hypovolaemia or spinal shock (patient with flaccidity and areflexia).



ASIA

STANDARD NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY

MOTOR

KEY MUSCLES

	R	L	
C2	☐	☐	
C3	☐	☐	
C4	☐	☐	
C5	☐	☐	Elbow flexors
C6	☐	☐	Wrist extensors
C7	☐	☐	Elbow extensors
C8	☐	☐	Finger flexors (distal phalanx of middle finger)
T1	☐	☐	Finger abductors (little finger)
T2	☐	☐	
T3	☐	☐	
T4	☐	☐	
T5	☐	☐	
T6	☐	☐	
T7	☐	☐	
T8	☐	☐	
T9	☐	☐	
T10	☐	☐	
T11	☐	☐	
T12	☐	☐	
L1	☐	☐	
L2	☐	☐	Hip flexors
L3	☐	☐	Knee extensors
L4	☐	☐	Ankle dorsiflexors
L5	☐	☐	Long toe extensors
S1	☐	☐	Ankle plantar flexors
S2	☐	☐	
S3	☐	☐	
S4-5	☐	☐	

0 = total paralysis
1 = palpable or visible contraction
2 = active movement, gravity eliminated
3 = active movement, against gravity
4 = active movement, against some resistance
5 = active movement, against full resistance
NT = not testable

☐ Voluntary anal contraction (Yes/No)

TOTALS ☐ + ☐ = ☐ MOTOR SCORE
(MAXIMUM) (50) (50) (100)

	LIGHT TOUCH R	LIGHT TOUCH L	PIN PRICK R	PIN PRICK L
C2	☐	☐	☐	☐
C3	☐	☐	☐	☐
C4	☐	☐	☐	☐
C5	☐	☐	☐	☐
C6	☐	☐	☐	☐
C7	☐	☐	☐	☐
C8	☐	☐	☐	☐
T1	☐	☐	☐	☐
T2	☐	☐	☐	☐
T3	☐	☐	☐	☐
T4	☐	☐	☐	☐
T5	☐	☐	☐	☐
T6	☐	☐	☐	☐
T7	☐	☐	☐	☐
T8	☐	☐	☐	☐
T9	☐	☐	☐	☐
T10	☐	☐	☐	☐
T11	☐	☐	☐	☐
T12	☐	☐	☐	☐
L1	☐	☐	☐	☐
L2	☐	☐	☐	☐
L3	☐	☐	☐	☐
L4	☐	☐	☐	☐
L5	☐	☐	☐	☐
S1	☐	☐	☐	☐
S2	☐	☐	☐	☐
S3	☐	☐	☐	☐
S4-5	☐	☐	☐	☐

0 = absent
1 = impaired
2 = normal
NT = not testable

☐ Any anal sensation (Yes/No)

☐ + ☐ = ☐ PIN PRICK SCORE (max: 112)

TOTALS{ ☐ + ☐ → = ☐ LIGHT TOUCH SCORE (max: 112)

(MAXIMUM) (56) (56) (56) (56)

SENSORY

KEY SENSORY POINTS

NEUROLOGICAL LEVEL
The most caudal segment with normal function

	R	L
SENSORY	☐	☐
MOTOR	☐	☐

COMPLETE OR INCOMPLETE? ☐
Incomplete = Any sensory or motor function in S4-S5

ASIA IMPAIRMENT SCALE ☐

ZONE OF PARTIAL PRESERVATION
Caudal extent of partially innervated segments

	R	L
SENSORY	☐	☐
MOTOR	☐	☐

Figure 20.11. Standard neurological classification of spinal cord injury.

21 THORACIC AND ABDOMINAL TRAUMA

THORACIC TRAUMA

Thoracic trauma is the leading cause of death in a quarter of all traumatic accidents. Severe thoracic trauma compromises respiratory and haemodynamic functions and aggravates the progression of other lesions, especially cerebral oedema secondary to traumatic brain injury.

The Initial assessment follows the A-B-C-D-E method as in any trauma. In assessing 'B', particular attention should be paid to:

- Examination of the thorax and breathing **(A)**.[203] A central cyanosis suggests hypoxemia (OR + 7.4. OR – 0.2).
- Determining respiration rate (normal: 10-25 breaths/min) **(B)**.[222 203] RF >27 or <10 breaths/min, suggests severe thoracic injury[223] and can predict cardiorespiratory arrest (OR + 3.1. OR – 0.6).[256]
- Auscultating the lungs, looking for unilateral diminished or abolished breathing sounds **(B)**.[203]
- Inspection of the neck for ingurgitation (suspected pneumothorax or cardiac tamponade) or collapse (suspected hypovolemic shock) of the jugular vein, or tracheal deviation.
- Inspection of the chest and observation of its movements: look for asymmetry, deformity, wounds, paradoxical breathing: the thorax sinks when breathing in and swells when expelled (suspect thoracic instability) **(C)**.[203]
- Palpation: look for pain, crackling, subcutaneous emphysema, instability **(C)**.[203]
- Thorax percussion: look for hyperresonance **(C)**.[203]
- If a pulse oximeter is available, measure the SpO_2 **(C)**.[203]

Treatment of thoracic trauma should be initiated —whenever possible— at the scene of the accident, especially in the following cases: tension pneumothorax, open pneumothorax, extensive unstable thorax, massive hemothorax and cardiac tamponade. In all cases, high oxygen flows are administered and if a pulse oximeter is available, it is adjusted to achieve an SpO_2 between 94 and 98%.

In the hospital, a forehead and thorax profile x-ray will be taken to assess: a) tracheal deviation, b) pulmonary parenchyma and pleura, c) mediastinum (normally the width of the vertebral bodies), d) diaphragm, e) bones, f) soft tissue, and g) tubes that may have been placed.

Lesions of the thoracic cage

Ribs fractures

These are the most frequent injuries in closed traumas.

- Complete fracture of the first three ribs: they can coexist with lesions of large mediastinal vessels, rupture of the tracheo-bronchial tree or complete fracture of cervical or dorsal vertebrae. Complete fracture of the first rib indicates blunt force trauma.
- Complete fracture of the 3rd-7th ribs: they may be associated with hemopneumothorax; when the parietal pleura ruptures, the appearance of subcutaneous emphysema is frequent.
- Complete fracture of the 8th-10th ribs: may be associated with abdominal injuries and rupture of the diaphragm.

The importance of complete rib fractures lies primarily in the fact that they cause pain. Pain causes hypoventilation and cough suppression with retained secretions. All of this leads to lung atelectasis that may become infected and lead to respiratory failure.

Diagnosis

- Pain and crackling on palpation.
- Radiology.

Treatment

- Analgesia: it is necessary to establish guidelines to avoid hypoventilation. Acetaminophen or acetylsalicylic acid may be given at a dose of 0.5-1 g, every 6-8 hours; ibuprofen at a dose of 400-600 mg, every 8-12 hours; or opiates if the pain is severe **(C)**.
- Adequate hydration and respiratory physiotherapy.
- Do not apply compressive bandages, as they worsen the mobility of the thorax.

Unstable chest

The term unstable chest or flail chest refers to the abnormal movement of the rib cage caused by the complete bifocal fracture (from two sites) of two or more contiguous ribs. The movements occur paradoxically in reverse with the respiratory movements, sinking the thorax when taking in air and swelling when expelling it. The degree of respiratory failure is related to the intensity of the underlying pulmonary contusion.

Diagnosis

- Presence of paradoxical respiratory movements.
- Pain with breathing and palpation.
- Bone crackling.

Treatment

- Analgesia as in complete rib fractures.
- Internal pneumatic stabilization: if there is respiratory failure, intubation and mechanical ventilation are maintained, so the patient will be hospitalised until the thorax is stabilised (10-15 days).

Care should be taken with fluid perfusion to avoid puddling in the lungs when fluids accumulate in the area of the pulmonary contusion.

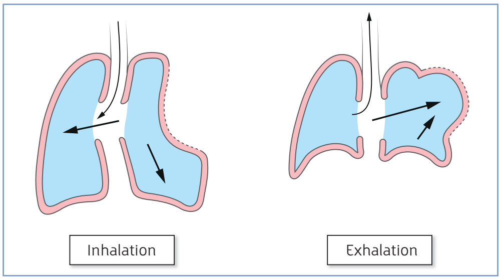


Figure 21.1. Unstable chest.

Fracture of the sternum

Complete sternum fracture occurs with moderate or severe direct impact to the front of the chest.

Painkillers and oxygen should be given if possible. Transfer to hospital to rule out cardiac or pulmonary contusion.

Alterations in the pleural space

Pneumothorax

The occupation of the pleural space by air that causes a partial or total pulmonary collapse.

a) Tension pneumothorax

Once total lung collapse has occurred, air pressure may continue to cause the mediastinum to divert to the contralateral side, compressing the other lung and causing severe respiratory failure and circulatory compromise due to difficulty in venous return, leading to a low cardiac output and shock.

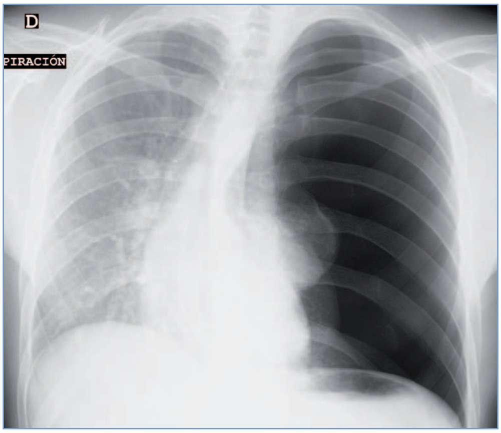


Figure 21.2. Tension pneumothorax.

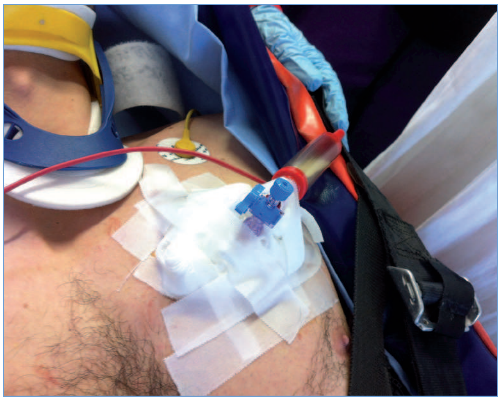


Figure 21.3. Tension pneumothorax emergency drain with Heimlich valve.

Clinical diagnosis

Suspected by decrease or abolition of respiratory sounds on the affected side **(B)**,[203] dyspnoea, tachypnea, jugular engorgement, hypotension, chest pain, tachycardia, subcutaneous emphysema in the thoracic or cervical region, tympanism at the percussion of the thoracic cavity, contralateral tracheal deviation, shock or suction of the thoracic wound.

Treatment

It is a situation that involves an immediate threat to life. If tension hemopneumothorax is suspected, it must be drained urgently **(A)**.[203]

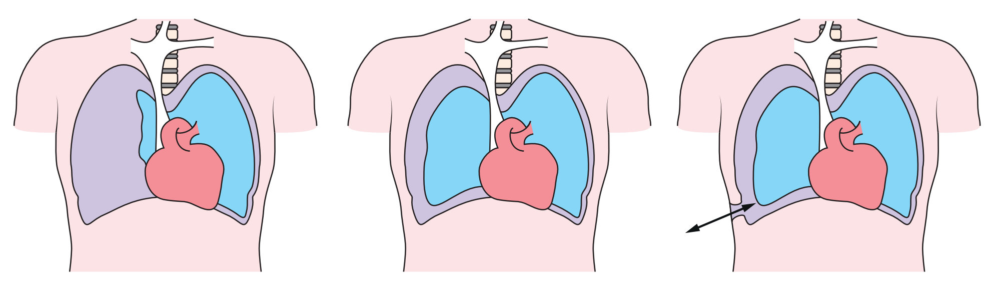


Figure 21.4. Pneumothorax.

Table 21.1. Signs and symptoms of tension pneumothorax[203]

	Blunt force trauma		Penetrating trauma	
	Sensitivity	**Specificity**	**Sensitivity**	**Specificity**
Auscultation: unilateral decrease or abolition of respiratory sounds	100 %	99.8 %	50 - 96 %	93-98 %
Dyspnoea and tachypnea	42.8 %	99.6 %	31.8 - 75.6 %	84.1- 99.2 %
Chest pain	57.1 %	78.6 %	25 %	91 %
Subcutaneous emphysema	12 - 25 %			

Table 21.2. Probability of clinically relevant hemopneumothorax, assuming a 10 % pre-test probability[256]

Chest pain Sensitivity 57 % Specificity 79 %	Dyspnoea Sensitivity 43 % Specificity 98 %	Auscultation Sensitivity 90 % Specificity 98 %	Probability of hemopneumothorax
+	+	+	>99 %
+	+	–	40 %
+	–	+	89 %
+	–	–	2 %
–	+	+	98 %
–	+	–	12 %
–	–	+	61 %
–	–	–	<1 %

Table 21.2. (Cont.) Probability of clinically relevant hemopneumothorax, assuming a 10 % pre-test probability[256]

Chest pain Sensitivity 57 % Specificity 79 %	Dyspnoea Sensitivity 43 % Specificity 98 %	Auscultation Sensitivity 90 % Specificity 98 %	Probability of hemopneumothorax
Hemothorax signs		OR +	OR –
Asymmetrical expansion		8.1	0.3
Decreased fremitus		5.7	0.2
Dullness		4,8	0.1
Decreased sounds on auscultation		5.2	0.1

In the prehospital setting, the insertion of a 14-16G angiocatheter is recommended (*Advanced Life Support Manual* by the Semicyuc polytraumatised patient) **(B)**.[203] If the Heimlich valve is not available, it can be improvised with a glove with the fingers cut out. The Heimlich valve does not protect against contamination and may become clogged. A thoracic tube should be inserted as soon as possible.

b) Simple pneumothorax

Only partial lung collapse occurs.

Diagnosis

- Respiratory insufficiency of variable degree.
- Decreased unilateral vesicular murmur.

Treatment

- Transfer to the hospital where thoracic drainage will be done if the pneumothorax is important.

c) Open pneumothorax

Collapse of the lung is caused by the entry of outside air into the pleural space.

Diagnosis

- Visual: a penetrating wound is observed on the chest with air inlet and outlet in relation to respiratory movements. Subcutaneous emphysema is associated.

Treatment

- Place a non-occlusive dressing on the wound with Vaseline gauze fixed to the skin with a three-point plaster, always leaving a free spot, so that it acts as a valve. They must extend beyond the wound by 5-7 cm. The air will come out in the exhalation and will not enter the inspiration. If Vaseline gauze is not available, a thin plastic square (plastic bag) can be used. There are chest seals with a built-in valve (Chest seals®).
- Transfer to the hospital where a decision will be made as to whether to have a surgical examination and thoracic drainage.

Hemothorax

Occupation of the pleural space by blood, as a consequence of a serious thoracic trauma.

Diagnosis

- When it is massive (>1,500 cm^3) it can lead to respiratory failure and hypovolemic shock.
- Absence of vesicular murmur, percussion dullness.
- Thoracentesis.

Treatment

- Thoracic drainage.
- Treatment for shock.
- Urgent thoracotomy if massive.

Pulmonary lesions

Pulmonary contusion

The trauma affects the lung tissue, presenting areas with oedema and haemorrhage, and altering the gas exchange function.

Signs and symptoms

- Respiratory insufficiency of variable degree.
- Haemoptysis.
- Feverishness, increased bronchial secretion.
- Auscultation: hypoventilation and crackles.
- Diagnosis is radiological.

Treatment

- Analgesia as in complete costal fractures.
- Treatment of acute respiratory failure.

Tracheobronchial rupture

Is associated with a complete fracture of the first three ribs.

Signs and symptoms

- Subcutaneous emphysema.
- Pneumothorax.
- Respiratory failure.
- Vocal changes, stridor.

Treatment

- Treatment of respiratory failure and tension pneumothorax if present.

Mediastinal lesions

Cardiac tamponade

Is a compression of the heart due to the accumulation of blood between the pericardium and the myocardium. Blood or fluid stored in the pericardium prevents the heart from fully expanding its chambers, so the heart cannot fill enough or pump blood.

Signs and symptoms of shock with distended jugulars (sensitivity 100%), tachycardia (sensitivity 100%), paradoxical pulse: systolic blood pressure may drop more than 12 mmHg (or more than 9%) when the patient takes a deep breath (OR + 5.9, OR – 0.03, sensitivity 98%),anxiety, chest pain that improves when sitting and leaning forward, shortness of breath, dizziness, pale skin, palpitations, hypotension, rapid breathing, dull heart sounds, weak or absent pulse.

Treatment: urgent pericardiocentesis, difficult to perform in the mountains **(B)**.[203]

Other

Rupture of the great vessels, oesophageal rupture, cardiac contusion (present in 10-20% of severe chest trauma, may cause arrhythmias), or diaphragmatic rupture.

ABDOMINAL TRAUMA

Non-penetrating injuries to the abdomen may cause:

- Contusion to the abdominal wall: in the first few hours it is difficult to know if there is a serious internal injury.
- Internal bleeding from ruptured liver, spleen, or kidneys. The liver is located in the upper right quadrant, the spleen in the upper left quadrant and the kidneys on both sides of the spine. The rupture of these organs causes blood to flow unimpeded to the abdominal cavity, causing haemorrhagic shock. The presence of haematuria is suggestive of renal injury. The patient must be referred to a hospital with the capacity to treat multiple trauma patients (interventional radiology, surgery, etc.).
- Rupture of other internal organs, such as the urinary bladder or bowel (infrequent).

Assessment

The Initial assessment follows the A-B-C-D-E method as in any trauma.

The crucial question is whether or not the abdomen should be operated on.

- If the injured person is conscious, assess the presence of spontaneous pain. The presence of pain referred to shoulder level with the injured person in Trendelenburg position may be due to the presence of blood, bile or intestinal contents in the abdominal cavity.
- Inspection of abdomen: look for bloating, bruising, wounds.
- Auscultation: the absence of bowel sounds may indicate the presence of paralytic ileus or peritoneal irritation, or may occur in complete spinal fractures.
- Palpation for pain, muscle defence. Remember that in the first moments there

is no abdominal defence and that certain spinal injuries can inhibit abdominal defensive contracture, and there can be visceral ruptures without abdominal defence.

- Percussion to see if there is air (tympanism) or liquid (dullness).
- If haematuria appears, renal trauma must be suspected.
- Pelvic trauma can be responsible for severe blood loss. Bilateral pelvic compression is painful when there is a complete fracture.

Intervention

- Initial assessment with A-B-C-D-E method.
- Treat the shock.
- In case of open wounds, cover them with sterile dressings.
- Transfer to hospital.

22 MUSCULOSKELETAL LESIONS

THE MUSCULOSKELETAL SYSTEM

The locomotor system supports the body and provides it with the necessary structure to move around. It is made up of bones, joints and muscles.

The bones are made of hard, resistant tissue. Inside them is the bone marrow, where blood cells (red blood cells, white blood cells, and platelets) are made. The set of bones forms the skeleton.

The skeleton is divided into well-differentiated parts:

- Skull and face.
- Spinal column.
- Rib cage.
- Upper limbs.
- Scapular waist: allows the upper extremities to relate to the rest of the skeleton through the shoulders, it is formed by the clavicles and the scapula or shoulder blades.
- Lower limbs.
- Pelvic girdle: it allows the lower extremities to connect with the rest of the skeleton through the hips, it is formed by the pelvis.

Joints are the structures that link bones together. There are fixed (skull), semi-mobile (vertebrae) and mobile (knee, elbow, etc.) joints.

The mobile joints consist of:

- Super Joint surfaces: part of the bones that are in contact with each other.
- Joint cartilage: covers the joint surfaces to prevent wear and tear.
- Joint ligaments: maintain contact and stability between joint surfaces.
- Articular capsule: defines the joint and stabilises it.
- Joint cavity: the space between the joint surfaces and the joint capsule.
- Synovial membrane: layer covering the inside of the articular cavity.
- Synovium: fluid secreted by the synovial membrane to lubricate the joint.
- Fibrous discs: these interpose between the joint surfaces of some joints to make them compatible (meniscus of the knees).

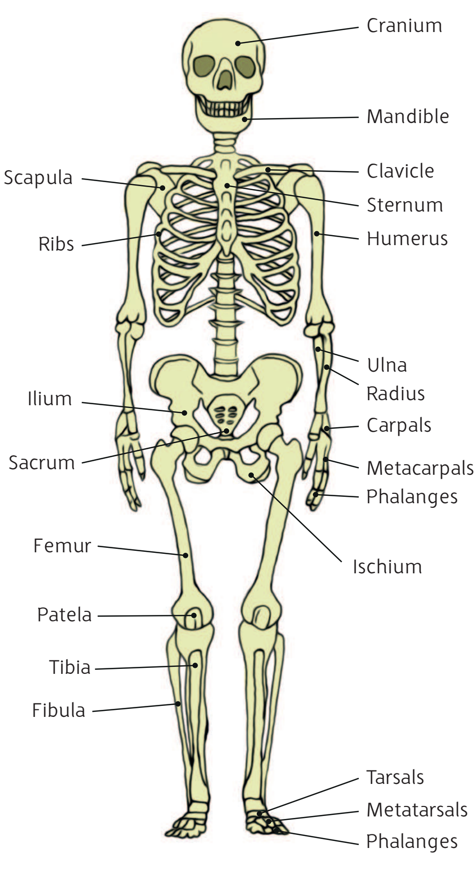

Cranium
Mandible
Scapula
Clavicle
Sternum
Ribs
Humerus
Ulna
Radius
Ilium
Carpals
Sacrum
Metacarpals
Phalanges
Ischium
Femur
Patela
Tibia
Fibula
Tarsals
Metatarsals
Phalanges

Figure 22.1. Skeleton.

The muscles represent the active element that ensures the dynamics (movements) and statics (posture) of the body.

PREVENTION OF MUSCULOSKELETAL LESIONS

Apart from food, hydration, and physical and technical preparation, proper equipment is very important to prevent muscle injuries, starting with good footwear that slips as little as possible or the use of crampons with anti-balling plates (remember that most mountain accidents occur when slipping on hard snow or long grass slopes then colliding with a rock), continuing with clothing that maintains a correct temperature in the muscle groups, and insisting on using the appropriate protective material for the activity to be performed (climbing and ski helmet, material in perfect condition for use, etc.). This subject is very well developed in mountaineering publications, so only the medical point of view on telescopic trekking poles and backpacks is mentioned.

Telescopic trekking poles

Telescopic trekking poles might reduce injuries to the lower limbs, spine and joints, reduce the strain on the respiratory muscles and warm up the arm muscles.

Their basic functions are:

- Reduce the weight supported by the knees, reducing muscle fatigue. During the descent, much of the stress and strain on the knee and hip joints passes to the top of the trunk, minimising premature body wear. There is controversy about reducing the burden on the knees with the use of poles, and more studies are needed.
- Help maintain balance, especially on difficult stretches.
- Relax your shoulders and back from the weight of your backpack.

When walking, the weight of the whole body plus the load of the backpack is supported on one leg. The pole provides a minimum of two support points at all times. The poles help to climb up slopes of up to 40° from the front. They also enable faster and safer descents, reducing the risk of falls, especially under heavy loads, and help to overcome obstacles. Using a pair of poles is like walking with four legs, as they spread the effort over all limbs and therefore offer greater safety than a single pole, especially on steep slopes.

The handles are useful to avoid getting caught in cracks or bushes, and not to sink into the snow. The large handles, ideal for winter hiking, prevent the pole from sinking into soft, deep snow. The small handles are more manageable and ideal for hard snow, ice and snow-free or lightly snowed areas. A shock-absorbing system installed on the handle or inside the baton softens the load on the elbow and shoulder joints.

During the ascent, the muscles of the arms, shoulders and chest also move, activating blood flow and respiration.

Use of trekking poles

When sticking the poles into the ground, the arms should be at a right angle (90°).

In descents, extend them so that the body retains the straightest posture possible.

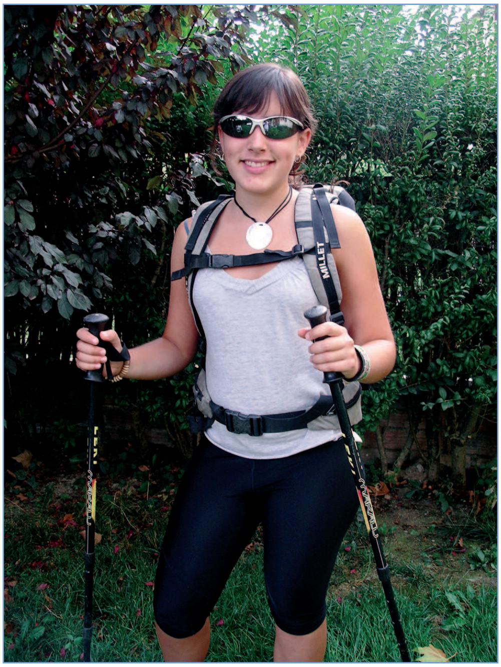


Figure 22.2. Correct position of backpack and poles.

In ascents, shorten them in order to carry the body forward.

On mid-slope flanks, adjust their length so that one is shorter than the other and the hands are at the same height. Do not use a pole without a handle when hiking in the snow, as it will sink with each stroke (Fig. 22.3).

Disadvantages

If the distance between the body and the poles is too great, the effort is not reduced and the mountaineer may become unbalanced. Continued use of the walking poles may decrease the walker's coordination and also their stability, although subjectively he or she may feel more secure. This disadvantage is more evident in difficult terrain. It is easier to learn how to maintain stability and use a proper walking technique without the help of poles than by using them regularly. Advantages and disadvantages must be assessed in every situation.

The backpack

The weight of the backpack should not exceed 10-15% of body weight. It must be supported by the legs and must be close to the centre of gravity. To avoid overloading the shoulders and spine, the backpack should have a belt that will hug the sides of the waist well and will not allow the backpack to slide downwards due to its weight.

The appropriate length of a backpack is measured by measuring the length between the 7th vertebra (base of the neck from behind) and the iliac crest. The purpose of the adjustment belts is to improve the transmission of the load to the centre of gravity. It is necessary to carry the backpack well, placing the maximum weight near the back and in the upper part of the backpack, at the level of the shoulder blades and shoulders.

MUSCULOSKELETAL LESIONS: GENERAL

Limb trauma accounts for about half of all injuries in mountain accidents.

Traumas do not usually represent situations of extreme urgency (with the exception of haemorrhagic shock caused by complete fractures of the pelvis or long bones), but should be treated in less than 6 hours to avoid major complications.

Types of musculoskeletal injuries:

- Complete fractures, if they affect the bones.
- Sprains and dislocations, if they affect the joint ligaments.
- Muscle injuries, if they affect the muscles.
- Compartment syndromes.

Complete and incomplete fractures

Consist of a loss of continuity in bone substance.

A complete fracture can be opened or closed:

- Open: there is a wound in connection with the fracture and there is the possibility that microorganisms may penetrate the fractured area from the outside.
- Closed: the skin is intact or the wounds are unrelated to the fracture.

A complete fracture can present several types of deformity:

- Displacement: one of the osseous ends has suffered a relative deviation with respect to the other.
- Angulation: the doctor must correct it because it can affect the function of the fractured limb and compromise the vessels and nerves.
- Rotation: movement of one of the two bone fragments along their axis, which is sometimes only seen on the x-rays that show the two ends of the bone.

Incomplete fractures are very fine fractures produced by a minimal trauma that is severe enough to produce a fracture, but not so much that it can be displaced. They can be difficult to see in an X-ray, so it is advisable to make oblique projections or repeat the X-ray after 7-10 days, when you can see them more clearly due to the decalcification that occurs in the core of the fracture.

Fractures from bone fatiguing due to stress are usually of this type and are often not diagnosed until the swelling from the osseous healing callus or the increased density at the site of the fracture occurs at 3-6 weeks after the onset of symptoms.

Incomplete fractures –except scaphoid and femur– usually heal quickly and require only symptomatic treatment.

Diagnosis

The Initial assessment follows the A-B-C-D-E method as in any trauma.

When complete fractures are not evident, they are suspected by medical history and examination and confirmed by x-ray.

The most common signs and symptoms are:

- Presence of a history of trauma.
- Severe, sharp, sudden onset pain in the affected area, although sometimes there are only tender spots when the bone is felt from any angle.
- Functional impairment: the affected limb cannot perform its normal function.
- Deformity: asymmetries of the contour or position compared to the other side.
- Point of impact, skin lesions or tumefaction of the affected area.
- The injured person may have noticed a cracking sound.
- In complete open fractures, the bone can be seen from the outside.

In case of uncertainty, act as if there were a fracture.

Treatment

The main objectives are: a) to achieve good bone healing without deformity, b) to restore function, and c) to prevent complications.

- Advise the injured person to remain in the most comfortable and least painful position.
- Remove any rings, bracelets or watches from the affected limb to prevent them from causing compression.
- As a general rule, the rescuer should not reduce the complete fracture and immobilise it in the position adopted by the injured person. If the deformity is so large that the skin is at risk of injury, an attempt is made to align (not reduce) by gently pulling the distal end of the limb.
- Assess the location, type, displacement, angulation, involvement of the skin, vessels and nerves. Suspect vascular rupture if there is bleeding, pulsating hematoma, or abnormal pulses. Suspect vascular compression if there is no pulse, paleness, tingling, or motor abnormalities.
- The doctor tries to reduce complete displaced fractures **(B)**. To do this, after checking for a distal pulse, apply gentle traction, usually on the limb axis to align all structures. If the distal pulse is lost after traction, stop and start it again before immobilising. Angulations observed after the traction can be corrected by placing one hand under the complete fracture and applying pressure with the other hand. Radiological testing should always be performed.
- Immobilising the affected limb-by prepadding the bony prominences-to improve pain, minimise bleeding, prevent fat embolism, and decrease the chance that a closed complete fracture will become open. The immobilisation should extend to the joint above and below the complete fracture **(A)**.
- Give analgesia if necessary **(A)**.
- If the complete fracture is open, it should be washed with antiseptic if possible, covered with sterile dressings, provisionally immobilised and treated with antibiotics **(B)**.
- Transfer to hospital.

Acute complications with fractures

Immediate

- Haemorrhaging with hypovolemic shock.
- Vascular lesions.
- Visceral injuries.
- Neurological injuries.

In the mid-term

- Pulmonary fat embolism possibly caused by the passage of bone marrow particles from the region of the complete fracture to the circulation. The mobility of the complete fracture core may be a contributing factor. It is more frequent in complete fractures of the femoral diaphysis and pelvis. Analgesia and immobilisation can prevent it.

Late

- Infection. If the evacuation is expected to take more than 6 hours, or if there are open complete fractures, 1 g amoxicillin with clavulanic acid or, in case of penicillin allergy, 500 mg of ciprofloxacin can be administered. Fluoroquinolones should be reserved for patients who have no alternative treatment options.

The complete fractures and dislocations most often associated with nerve paralysis are:

- Shoulder dislocation: paralysis of the circumflex nerve, rarely other brachial plexus injuries.
- Complete fracture of the humerus diaphysis: radial nerve paralysis.
- Elbow dislocation: paralysis of the ulnar nerve, sometimes with involvement of the median nerve.
- Complete fractures of the elbow region: median nerve paralysis, rarely ulnar or posterior interosseous.
- Hip dislocations: paralysis of the sciatic nerve.
- Dislocation of the knee or rupture of the lateral ligament with complete fracture of the inner part of the tibial plateau: common peroneal nerve paralysis or external popliteal sciatica.

Table 22.1. Exploration of the peripheral nerves of the upper limbs

Nerve	Motility	Sensitivity	Injury
Ulnar	Index abduction Deltoid motility	Little finger	Elbow injury
Distal medium	Opposed thenar contraction	Index	Wrist dislocation
Median anterior interosseous	Flexion of the fleshy part of the index finger		Complete fracture of the supracondylar humerus
Musculocutaneous	Elbow flexion	External region of forearm	Anterior shoulder dislocation
Radial	Thumb motility, metacarpophalangeal extension of fingers	First dorsal interdigital space	Distal diaphysis of the humerus Anterior shoulder dislocation
Axillary	Motility of the deltoid	External shoulder region	Anterior shoulder dislocation Complete fracture of proximal humerus

Table 22.2. Exploration of the peripheral nerves of the lower limbs

Nerve	Motility	Sensitivity	Injury
Femoral	Knee extension	Anterior knee region	Complete fracture of pubic branches
Obturator	Hip abduction	Middle of the thigh	Complete fracture of the obturator ring
Tibialis posterior	Bending of the toes	Foot sole	Dislocation of the knee
Superficial peroneal nerve	Eversion of the ankle	External dorsal region of the foot	Complete fracture of the neck of the fibula
Deep peroneal nerve	Dorsal ankle flexion	Motility of the first and second dorsal interdigital spaces	Dislocation of the knee
Ciatic	Plantar dorsal flexion	Foot motility	Complete fracture of the neck of the fibula
Superior gluteal nerve	Abduction of the hip		Compartment syndrome
Inferior gluteal nerve	Gluteus maximus motility Extension of the hip		Posterior dislocation of the hip

Table 22.3. Injuries associated with complete fractures

Lesion	Associated injuries that may go unnoticed
Complete clavicle fracture Complete scapula fracture Complete shoulder fracture/luxation	Pulmonary contusion, complete rib fractures
Complete displaced thoracic spine fracture	Complete thoracic aorta fracture
Complete fracture of spine	Intra-abdominal injury
Complete elbow fracture/luxation	Injury to the brachial artery Injury to the median, ulnar, and radial nerves
Pelvic fracture	Retroperitoneal haemorrhage
Complete fracture of femur	Complete femur neck fracture Posterior dislocation of the hip
Posterior knee dislocation	Complete femur fracture Posterior dislocation of the hip
Knee dislocation Complete displaced fracture of tibial plateau	Popliteal nerve and artery injuries
Complete calcaneal fracture	Complete spinal fracture or injury Complete fracture or injury to the heel Complete fracture of tibial plateau
Complete open fracture	70% of the cases have associated non-skeletal injuries

Priority of fracture care

Table 22.4. Scale of priority of care for complete fractures

Life threatening complete fractures with a risk of haemorrhagic shock	Massive complete open fractures Complete bilateral femoral fractures Complete fractures with associated vascular lesions (elbow, knee) Complete pelvic fractures Limb amputations
Complete fractures with a risk of affecting limb function	Complete joint fractures Dislocations Crush injuries Complete simple open fractures
Low-risk complete fractures	All the rest

Dislocation, subluxation and sprain

Dislocation: consists of a complete loss of contact between the joint surfaces, the bones that make up the joint are displaced from each other.

Subluxation: the loss of contact is not complete.

Table 22.5. Common dislocation deformities

Joint	Management	Deformity
Shoulder	Anterior Posterior	"Squared off" (boxlike), stuck in internal rotation
Elbow	Posterior	Posterior prominence of the olecranon
Hip	Anterior Posterior	Abduction with external rotation Abduction with internal rotation
Knex	Anteroposterior	Extension with a loss of normal contour
Ankle		External rotation with prominence of the tibial malleolus

Sprain: an incomplete tear of a ligament or complex of ligaments responsible for the stability of a joint. It also applies to the incomplete rupture of muscles or tendons.

Diagnosis

Common symptoms and signs:

- Pain.
- Swelling.
- Bruising.

Differentiating signs and symptoms:

- Sprain: The joint can move even if it causes pain.
- Dislocation: functional impotence and joint deformity.

If in doubt, act as if there were a dislocation.

Treatment

Sprain

- Keep the joint at rest.
- Localised cold: 15-20 minute sessions every 4-6 hours, ice or snow should be wrapped in cloth to avoid cold injury.

Dislocation and subluxation

- Immobilise the joint in the most comfortable position for the patient.
- The doctor will assess the possible reduction in dislocation **(B)** taking into account possible complications.
- Transfer to hospital.

Muscular lesions[303]

Muscle injuries are characterised by pain and functional impairment.

Table 22.6. Classification of muscle injuries

Type	Prognosis
Contracture and/or muscle stiffness (DOMS)	1-3 days
Fibrillary microbreaking and/or muscle elongation	3-15 days
Fibrillary rupture	3-8 weeks
Muscle breakdown	8-12 weeks

In contractures and stretches, there is often a history of unusual straining or flexibility exercises. In ruptures, the injured person remembers the time of injury. Sometimes there is bruising or pain on palpation or with movement.

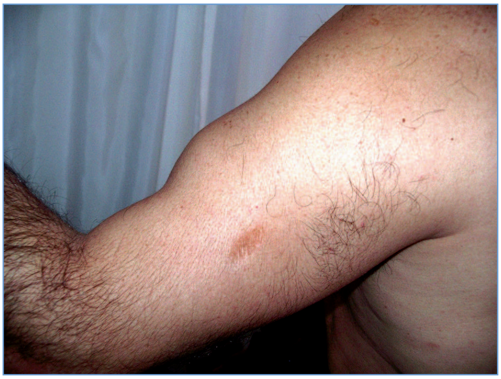


Figure 22.3. Muscle tear.

Cramps

They are spasmodic muscle contractions, usually of the legs, that can last 15 minutes or more. Possibly due to changes in the excitability of the motor neuron.[124]

Risk factors include exercise-induced muscle fatigue, dehydration, and loss of sodium from excessive sweating.[121]

They can be prevented by drinking plenty of liquids containing salt.

Treatment (C)

- Stretching the muscles.
- Drinking salty liquids.
- Physiological saline solution.
- Refractory muscle cramps may improve with benzodiazepines.

Muscle stiffness (DOMS)

Is part of a process of adaptation to exercise and is due to microscopic muscle injuries caused by mechanical work in muscle fibres that are not prepared for it, either because they are fatigued, because they are not the right fibres for the job (generally fast fibres) or for both reasons. The affected area is usually the muscle-tendon zone, as it is at the transition point from the contractile zone to the elastic zone where the muscle fibres are most stressed. Cell breakage releases substances that cause pain and inflammation. The inflammation causes oedema that compresses the nerve fibres and increases discomfort. The swelling will decrease when new exercise is performed, with the consequent decrease in compression on the nerve fibres and a decrease in pain.

The plasma level elevation of the muscle enzymes creatine kinase (CK) and lacto dehydrogenase (LDH) indicates the existence of the lesion, but not its greater or lesser intensity, severity or size.

Treatment

The application of localised cold (ice wrapped in a cloth), after the practice of exercises in which the use of a certain group of muscles has been increased, can improve the symptoms. When the aches and pains have already appeared, you should warm up for a longer period of time before a new exercise, as well as give a superficial massage. If necessary, an analgesic can be administered. The recovery period is 3 to 5 days, but a full recovery will not occur until after 7 to 15 days.

The name "*agujetas*" in Spanish equates to "little needles" and it originates from the popular belief that it was due to the crystallisation of sodium lactate in the muscle and that pierced into to the muscle when it moved. It was also believed that the practice of gentle exercise untangled these crystals by the mechanical effect of the movement and thermal effect of heat. Lactate does not crystallise at body temperature and has not been observed in muscle biopsies, and is quickly reused by the body, so it does not build up. Also, sodium bicarbonate has not been shown to be helpful for the prevention and treatment of muscle soreness.

Acute muscular lesions

Treatment **(C)**[304]

During the first three days:

- Protection.
- Rest from sports.
- Localised cold: 15-20 minute sessions every 4-6 hours, ice or snow should be wrapped in cloth to avoid cold injury.
- Compression.
- Elevation.

From the 3rd day onwards: early mobilisation and optimal loading.

The use of NSAIDs during the first 48-72 h is not harmful and does not interfere with the regeneration phase if their use is not continuous **(A)**. Muscle relaxants may be used.

Compartment syndromes

The muscles are surrounded by a very rigid sheath or compartment. Oedema of these muscles after trauma, usually from crushing, can compress the blood vessels supplying the muscle itself due to the lack of flexibility of the sheath; as the blood supply decreases, ischaemia or necrosis of the muscle tissue occurs.

Diagnosis

Pain, swelling (usually hard as a stone), weakness, paraesthesia or paralysis of the affected muscles, the pulse may be maintained.

Treatment

- Remove any tight clothing or bandages.
- Transfer to hospital for an emergency fasciotomy **(A)**.[203]

DRESSINGS AND IMMOBILISATIONS

Dressings

Bandages are used to hold dressings, cover wounds, fix splints, and even hold and immobilise limbs.

Rules for a correct bandaging:

- Place the area to be bandaged in the most comfortable and functional position possible.
- Start the dressing with a slightly oblique wrap relative to the limb axis, followed by a circular one. The protruding tip of the bandage is then folded over and another wrap is made to fix the folded tip.
- Initiate the dressing on the distal part of the affected limb, progressing toward the proximal part (from the foot to the thigh and from the hand to the shoulder).
- Bandage from left to right (reverse if the rescuer is left-handed), with the roll of the bandage on top (the hand next to the ski patrol member).
- During the bandaging, the bony protrusions, the natural cavities (armpit, etc.) and the corners (interdigital space) must be protected with cotton or similar.
- Finish the dressing with two circular turns perpendicular to the axis of the extremity. Do not knot over the wound or injured area.

Table 22.7. Functional position of the joint to be taken into account when bandaging

Joint	Functional position
Shoulder	Arm against lateral thorax
Elbow	90° flexion
Wrist	Dorsal flexion at 20º
Metacarpophalangeal	Flexion at 45º

Table 22.7. (Cont.) Functional position of the joint to be taken into account when bandaging

Proximal interphalangeal	90° flexion
Distal interphalangeal	Flexion at 45°
Hip	Extension
Knee	Flexion at 20°
Ankle	90º between foot and leg

For Velpeau bandage with fabric triangle, the vertex of the triangle is placed at the level of the elbow, so that the triangle is between the extremity and the trunk of the injured person. The ends of the base of the triangle are then directed upwards, each passing one side of the neck and knotted on the nape of the neck.

Immobilisations

Complete fractures are immobilised to prevent displacement during healing.

- Immobilise at least one joint above and one joint below the fracture site so that the fracture site cannot move.
- Leave fingers uncovered to check for signs and symptoms of excessive pressure on the bandage (bruising of the fingers, loss of sensation, paraesthesia, etc.).
- Splints are used to keep the injured limb in a functional and immobile position. Two splints are often used, one for the inside of the injured limb and one for the outside.

The most commonly used splints in mountains are:

- Vacuum splints and mattresses: this is a plastic wrap filled with pellets. The sheath is adapted to the affected extremity and the vacuum is formed with a pneumatic pump, so that the pellets are squeezed together until they reach sufficient rigidity to immobilise the extremity. If you want to immobilise the whole body, you can use a vacuum mattress.
- Mouldable splints (SamSplint® type).
- Kramer splints: these are ladder shaped wire splints covered with padding. They can be replaced by Sam® Splints, which are more manageable in the mountains.
- Kendrick›s spinal splint (Ferno-KED).
- Improvised splints using sticks, branches, ski poles, ice axes, etc.

Immobilisation with a plaster cast or splint

In the ski and mountain resorts, health workers with specific equipment are usually available for immobilising with plaster splints and bandages, so here some of the basic rules explained:

- First, the skin is protected with an elastic tubular bandage. This bandage is folded over the plaster once it has been placed and trimmed, leaving about 4 cm. The free edge is then secured with a couple of turns of plaster bandage if it is a closed plaster cast, or with a gauze bandage if it is a plaster splint.
- Before the cast is placed, the bony prominences are protected with cotton or similar. If oedema is expected, the entire limb is protected.
- Gypsum splints consist of several layers of plaster bandage and are used to treat minor injuries or when a potentially severe oedema is anticipated in a complete fracture. Before applying them, the necessary length is cut off and trimmed to adapt it to the extremity. On children 6 layers may be enough, while an adult will need 8 or 10 layers. Before the splint is wetted, the end of the bandage is bent inward so that it does not lose alignment. To wet it, take it on both sides, dip it in warm water, stretch it and leave it hanging for a moment to remove excess water. The layers are then placed on the table and pressed together with the edge of the hands from the centre outwards to consolidate the different layers of plaster. If no table is available, consolidate the layers by holding the splint at one end and stretching it down between two fingers.
- It is then placed on the limb and smoothed so that no folds form on its inner surface. The weak parts are then reinforced with small splints.
- The splints are secured with open weave bandages (cotton) that are pre-wetted to prevent compression that can occur if they shrink when they come into contact with

the wet splint. They are then drained and applied firmly, but without too much pressure and without turning in on themselves to avoid local constriction.

- The bandage is secured with a plaster bandage. The plaster bandage is soaked in lukewarm water, holding the end in one hand so that it does not get mixed up with the rest, and, without compressing it, it is immersed at a 45º angle until no more bubbles appear. Excess water is removed by gently squeezing it in the axial direction and twisting it slightly. Each turn of the bandage should be placed 2-3 cm from the previous one.
- If an intense tumefaction is anticipated, it is preferable to use an open splint or place a large layer of cotton under the cast. Once plastered, the plaster is opened with a scalpel along its entire length until it reaches the cotton layer.
- The limb should be raised until the oedema subsides. Gypsum-free regions should be moved as often as possible.

Subsequent monitoring of a patient in plaster

- If there is inflammation, circulatory disturbance should first be ruled out and, once it has been ruled out, elevation of the limb and stimulation of movement should be recommended.
- If the fingers become cyanotic, it means that the tumefaction is so intense that the cast is too tight and must be cut lengthwise to decompress or change it.
- Signs of arterial obstruction are: pain, paralysis of the flexors of the fingers, tingling, paleness, and a feeling that the fingers are frozen. The cast should be cut and loosened until the skin is exposed and, if circulation has been restored, the space through which the cast was cut should be gently filled with cotton and bandaged with a crepe bandage. The limb is then lifted. If circulation does not return, the complete fracture should be re-evaluated and large vessel injuries suspected.
- When a plaster cast or open cast has been placed, it may be considered for completion after 2-4 days if the tumefaction has decreased.
- Reinforce weak or cracked areas.
- Check that the cast does not limit movement, is not too short or has become too loose. If there is localised pain, a window should be opened in the cast to inspect the area.

THE MOST COMMON FRACTURES AND DISLOCATIONS OF EXTREMITIES IN THE MOUNTAINS

Various treatments are suggested depending on the availability of means (mountain, ski resort medical service, emergency service, etc.).[305, 306]

Fractures and dislocations of hands and fingers

General treatment: bandage the entire hand in a functional position (as if holding a tennis ball), lift it with a sling, and transfer to hospital.

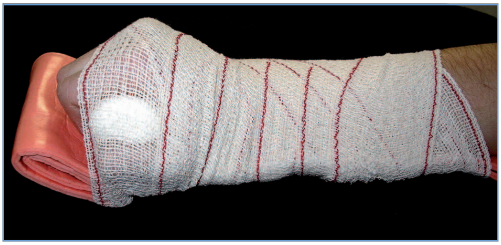


Figure 22.4. Immobilisation of hand and fingers.

Fractures and dislocations of finger phalanges, excluding the thumb

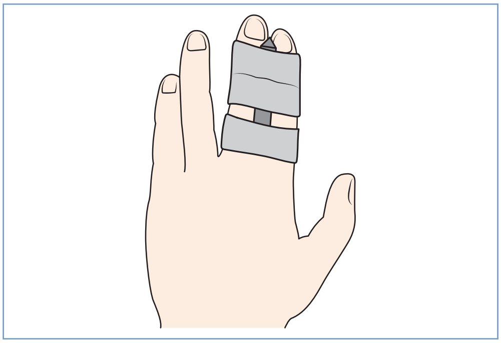


Figure 22.5. Immobilisation for phalanx complete fracture.

Treatment: immobilise the injured finger by placing gauze between that finger and the next one. Then join the two fingers together with adhesive tape (surgical tape or similar), leaving the nail bed exposed to control the proper circulation of blood.

Metacarpal and phalangeal fractures, excluding the thumb

Treatment: aluminium splint or dorsal plaster splint depending on the severity of the fracture.

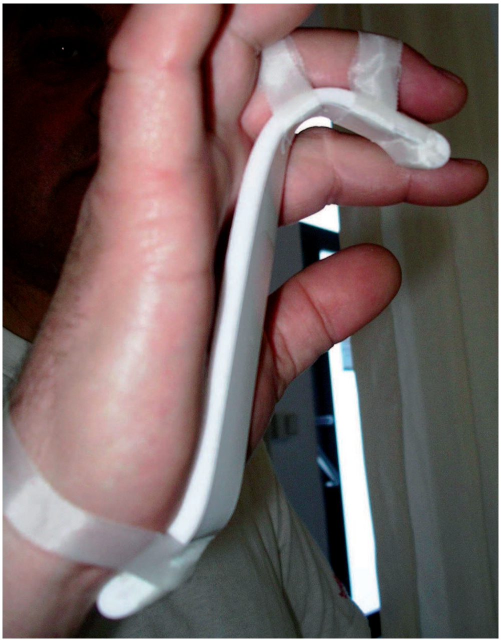


Figure 22.6. Immobilisation of fingers with aluminium splint 1.

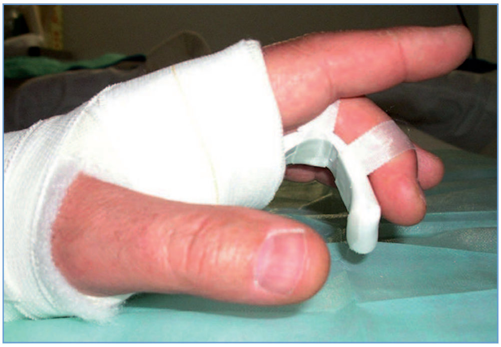


Figure 22.7. Immobilisation of fingers with aluminium splint 2.

Interphalangeal dislocations

A loss of contact between the surfaces of the head and the base of two adjacent phalanges. They are usually posterior.

Mechanism: a blow or forced hyperextension.

Exploration

- Inspection: deformity of the finger with loss of bony relief, finger in extension.
- Palpation: abnormal reliefs.
- Mobility: functional impotence and elastic stiffness.

Treatment

- If there is no associated complete fracture, a reduction can be attempted by performing finger traction.
- Immobilise with a digital semi-flexible splint and refer to the hospital for reduction, fixing, if necessary, to the adjacent healthy finger to increase the strength of the bandage. Digital splints are always placed with the finger flexed, as if holding a sphere, extending to the wrist. Try to place the metacarpophalangeal joints at a 90° angle of flexion, the interphalangeal joints in extension and the thumb in abduction.

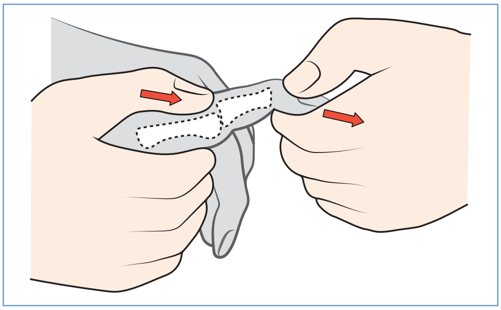


Figure 22.8. Reduction of a dislocated interphalangeal joint.

Dislocation of the metacarpophalangeal thumb joint

Mechanism: secondary to forced thumb hyperextension.

Treatment

- Reduction can be attempted by making a quick traction of the thumb, while simultaneously pressing the metacarpal head.
- Immobilise in functional position and refer to the hospital for reduction.

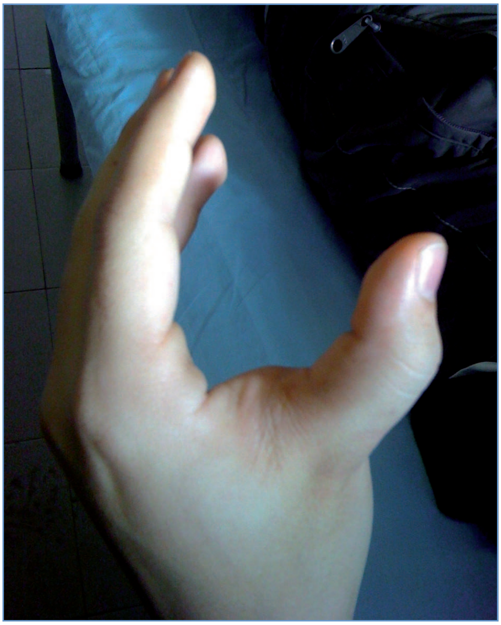


Figure 22.9. Thumb luxation.

Rupture of the inner lateral ligament of the thumb

If left undiagnosed and untreated, it can produce a progressive metacarpophalangeal subluxation that will affect the thumb-clamp movement and result in a permanent disability.

Mechanism: secondary to a forced hyperextension of the thumb.

Examination: fully extend the metacarpophalangeal joint and force the internal lateral ligament by abducting the proximal phalanx. Then repeat with the thumb bent, you will feel the joint give way. Tenderness on the inside of the joint can be painful (Fig. 22.10).

Treatment

- Immobilise in a functional position and transfer to hospital.

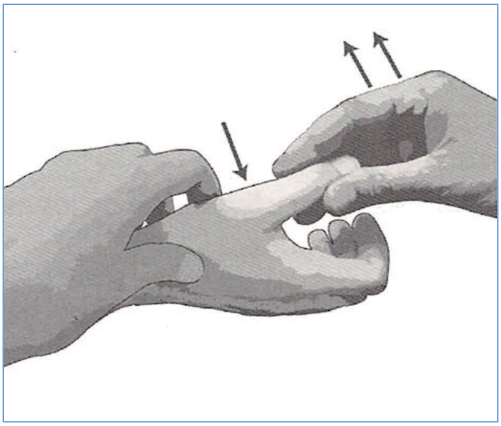


Figure 22.10. Examination of the inner lateral ligament of the thumb.

- If the laxity is mild (incomplete rupture) it is treated with a scaphoid cast for six weeks.
- If it's major, surgery is required (Fig. 22.11).

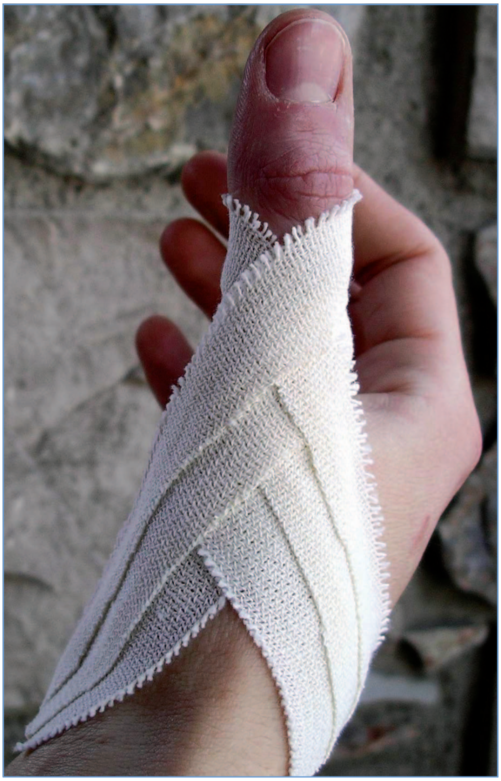


Figure 22.11. Functional thumb taping procedure.

Finger lesions produced by climbing

Figure 22.12. Rock climbing.

Just as the injuries characteristic of classical climbing involve violent trauma, sport climbing is characterised by overload injuries.

Around 75% of sport climbing practitioners suffer some injury to the upper limbs, especially the hand or wrist, the most frequent being an injury to the flexor tendon of the fingers or their pulleys, especially the A2, followed by the A4 when using the crimp rock climbing holds with arched fingers.[307-314]

The flexing of the fingers is very powerful. The muscles responsible for the flexion run through slides (sheaths) to ensure the pulley effect. Repeated use and high stress on the tendon can cause the sheath to swell or break.

The most frequent injury is the rupture of a pulley at the base of the first phalanx of the 4th or 3rd finger. This break appears with an arched finger and results in a noise accompanied by intense localised pain, which may radiate to the palm of the hand or even the elbow. Usually, a tumefaction will appear and flexion against the resistance of the distal phalanx will be painful.

Tendons can also be injured, resulting in microscopic lesions that sometimes do not heal well and form a fibrous tissue that thickens the tendon. This thickened tendon will not run well through the sheaths and will become a difficult lesion to treat.

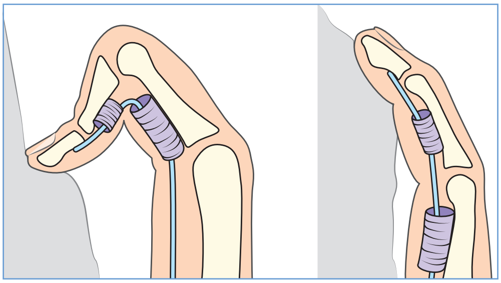


Figure 22.13. Climbing injuries.

Other overuse injuries related to sport climbing include medial epicondylitis, brachial and bicep tendinitis, elbow ligament injuries, carpal tunnel syndrome, rupture of the collateral ligaments of the interphalangeal ligaments and interphalangeal arthritis.

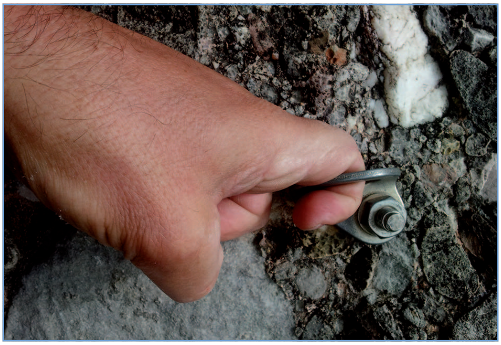


Figure 22.14. Finger caught in a climbing anchor.

Prevention

Preventive measures consist of warming up before climbing, moisturising well, avoiding the cold and remembering that the more the

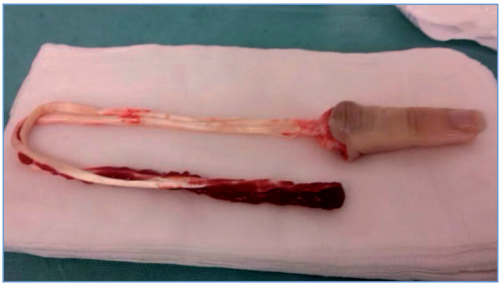


Figure 22.15. Tearing off distal phalanxes after a fall with the finger in a climbing anchor.

tendons are flexed, the more tension the pulleys receive and the more chance they have of breaking, so the use of a specific training plank is not advisable. Modifying the blocking technique by using extension grips may reduce injuries to the flexor tendons of the hands. Taping may be useful for protection, although its effectiveness is controversial.[315]

There is a relationship between the degree of difficulty and the number of hours of climbing, and the probability of suffering an injury.

Table 22.8. Treatment of pulley injuries[314]

	Grade 1	Grade 2	Grade 3	Grade 4
Injury	Sprain	Complete rupture A4 or partial rupture A2 or A3	Complete rupture A2 or A3	Multiple ruptures (A2/A3, A2/A3/A4) or single rupture (A2 or A3) combined with muscle or tendon injury
Treatment	Conservative	Conservative	Conservative	Surgical
Immobilisation	No	10 days	10-14 days	Postoperative 14 days
Functional treatment	2-4 weeks	2-4 weeks	4 weeks	4 weeks
Pulley protection	Functional bandage	Functional bandage	Thermoplastic ring	Thermoplastic ring
Beginning of soft sports activity	4 weeks	4 weeks	6-8 weeks	4 months
Full sports activity	6 weeks	6-8 weeks	3 months	6 months
Functional climbing bandage	3 months	3 months	6 months	>12 months

Treatment

Fractures affecting the forearm

Complete wrist fractures are most frequent in snowboarders, accounting for 12.3% of injuries in this group[316] and could be reduced by 71% with the use of wrist protectors.[281, 317]

Rule for suspecting complete wrist fracture[318]

This clinical decision rule is 100% sensitive and 37.7% specific in detecting patients with positive radiological imaging of the wrist in acute trauma.

- Age 35 years or older.
- Oedema on the back of the wrist.
- Limitation of supination or active radial deviation.
- Pain or instability in the distal radius and ulna snuffbox test.

General treatment: immobilise the wrist straight and the elbow at 90º.

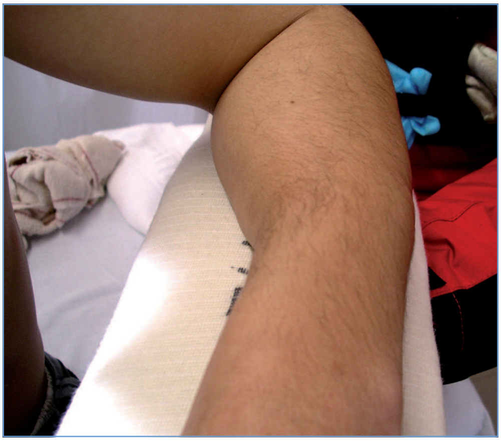


Figure 22.16. Complete fracture of ulna and radius.

Scaphoid fracture

The most frequently fracture of a carpal bone.

Mechanism: falling on the hand in dorsal flexion or a direct blow to the dorsal region of the hand below the radial styloid.

Exploration

- Inspection: in recent injuries, there may be oedema of the anatomical snuffbox (small hole in the wrist area that can be seen when the thumb is raised up).
- Palpation: pain at the digital pressure of the anatomical snuffbox.
- Mobility: pain and limited movement of the wrist.

The pain on palpation of the anatomical snuffbox has a sensitivity of 100%, i.e., if there is no pain, the presence of complete fracture is very unlikely. A high specificity is achieved by finding pain on palpation of the anatomical snuffbox, the scaphoid tuber and by axial compression of the thumb.[319].

In the event of clinical suspicion, even if the radiology is negative, the patient should be immobilised and the radiology should be repeated after 15 days, by which time the bone resorption makes the focus of a complete fracture more visible.

Treatment

- Immobilise in functional position and transfer. Immobilisation of complete scaphoid fractures usually involves the thumb being immobilised up to the interphalangeal joint, although it appears that the thumb position does not affect the displacement of the complete fracture, as long as the wrist is not in ulnar deviation; therefore, a standard wrist splint could be used, with these precautions.[320]
- Immobilise the wrist in full pronation, radial deviation, moderate dorsiflexion and thumb in intermediate abduction. A splint is made with 6-8 layers of 10 cm plaster, the proximal angles are trimmed and a distal cut is made to adapt it to the thenar muscles. An elastic tubular bandage is placed from above the elbow to the proximal phalanges, the wrist is protected with cotton.
- The plaster splint is then placed, taking care not to exceed the proximal palmar fold, and then a circular bandage with a plaster bandage of 15 cm for the forearm, 10 cm for the wrist and 7.5 cm for the thumb is applied.

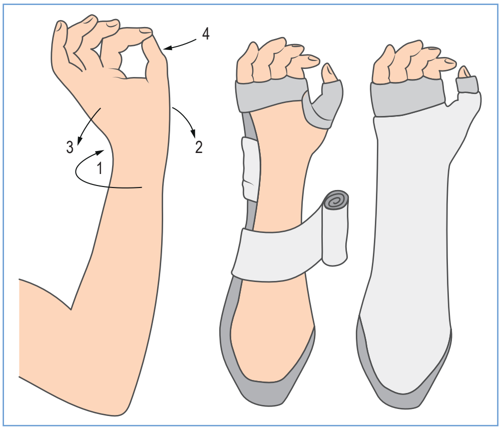


Figure 22.17. Immobilisation of complete scaphoid fracture.

- Avoid immobilising the joints of the distal phalanx of the thumb and elbow.

Immobilisation time: 8-12 weeks.

Distal radius fracture

A complete fracture is the most common (affecting the entire bone cortex) with posterior (dorsal) deviation of the distal fragment (complete Colles' fracture).

Mechanism: fall on the hand in hyperextension.

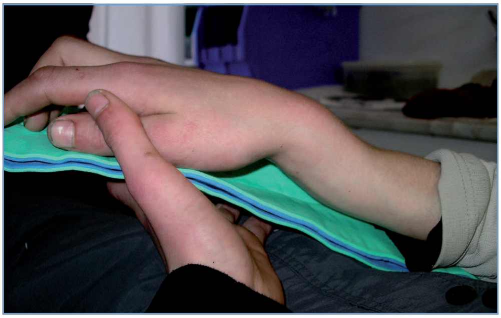


Figure 22.18. Complete fracture of wrist. Back of fork image.

Exploration

- Inspection: back of fork appearance.
- Palpation: defective protrusion of bone continuity in the dorsal face of the arm.

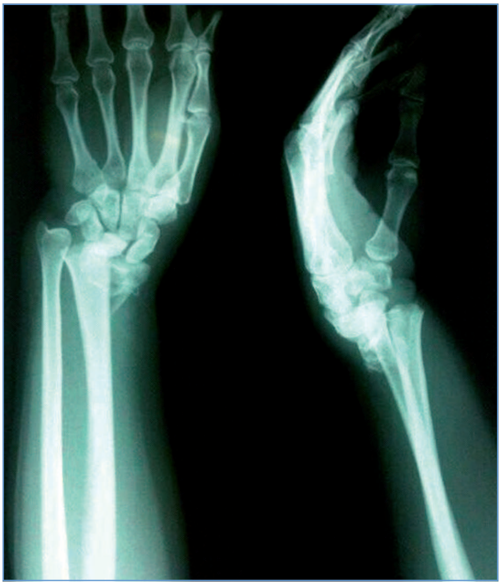


Figure 22.19. Radiology of a complete wrist fracture.

Selective pressure pain at the site of the complete fracture.

- Mobility: functional impairment.
- Whenever a complete Colles' fracture is diagnosed, associated scaphoid, elbow and shoulder injuries should be ruled out.

Treatment[321, 322]

- Compressive bandage and transfer to hospital.
- Medical service with adequate resources:
  - If there is neurovascular compromise and it is estimated that the transfer to hospital will take more than 6 hours, reduce the complete fracture.
  - Before manipulation, prepare a dorsal plaster cast: the length should be equal to the distance between the olecranon and the heads of the metacarpals. The width, about six inches. It should be 8 turns thick and a tongue for the first interdigital fold should be trimmed, a large curve on the radial side to allow elbow flexion and a cut-out to allow ulnar deviation.
  - Reduction:
    - Infiltrate the complete fracture site with 5-10 mL of local anaesthesia. Flex the elbow at a right angle and have it held by an assistant with interlocked fingers; then apply traction in the direction of the forearm axis. By reducing, the disimpaction of the distal fragment is checked, which, caught between the thumb and index finger, can easily move in the anterior and posterior direction.
    - Next extend the elbow, place one hand on the dorsal surface of the distal radius fragment with the fingers curved over the wrist and palm of the injured person's hand and, using the other hand as a support point, apply anterior pressure to correct the remaining deformities. Maintaining traction, change position so that the heel of the hand is able to push the distal fragment towards the ulna to correct the radial displacement.
    - Change the position of the hands to facilitate placement of the cast: one hand holds the thumb in full extension, and the other, the three central fingers, maintaining a slight traction; the arm should be in full pronation and the wrist in full ulnar deviation and slight palmar flexion.

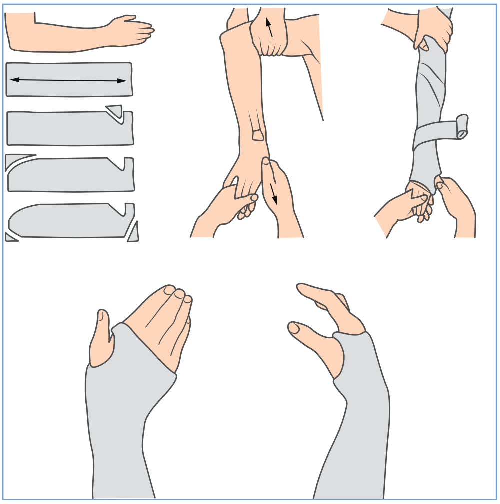


Figure 22.20. Reduction and immobilisation of a complete wrist fracture.

- Immobilisation:
  - Protect the plaster splint with cotton and place it so that it covers the front, outer and back sides of the radius, the tongue is folded towards the palm and held in place with two wet 10 cm bandages.
  - Remember that the cast must be placed on the ulnar deviation without excessively flexing the wrist.
  - Flex the elbow to more than 90° with the hand higher than the elbow and the move fingers early to avoid oedema.
  - Immobilisation: 4-6 weeks.
- If the complete fracture is suspected to have multiple fragments, or to affect the joint veneer, or the fragments are aligned incorrectly, begin by sending the patient to hospital having done an immobilisation with a forearm splint with 8-10 layers of 15 cm wide plaster bandage to prevent the movement of the core of the complete fracture.

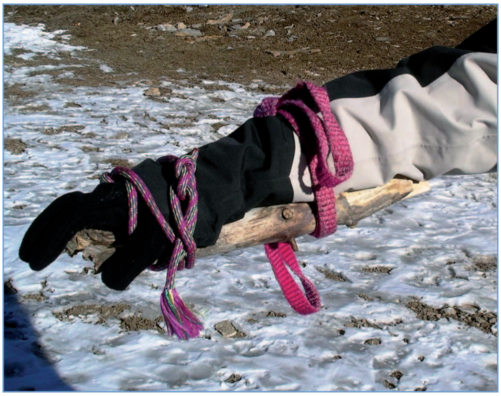


Figure 22.21. Wrist immobilisation splint.

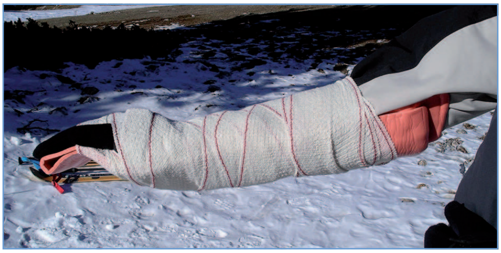


Figure 22.22. Wrist immobilisation with a mouldable splint.

Fractures affecting the elbow, arm and shoulder

General treatment: sling and transfer to hospital.

Fractured humerus

Examination: pain and unstable arm. Explore the function of the radial nerve (active extension of the fingers and wrist).

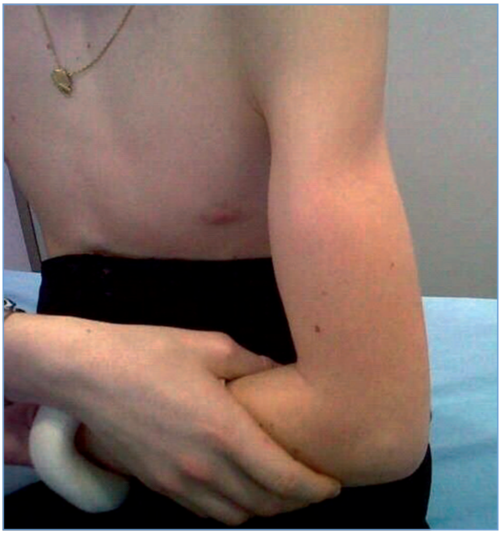


Figure 22.23. Complete fracture of humerus.

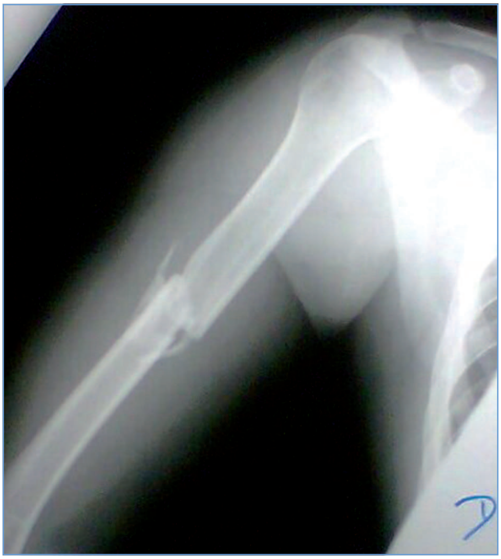


Figure 22.24. Radiology of complete fracture of humerus.

Treatment[323]

- Splint or sling and transfer to hospital.
- In complete fractures of 1/3 proximal, if they are stable, a Velpeau bandage is applied, and if they are comminuted, a sling is applied.
- In complete fractures of the diaphysis or supracondylar, a posterior splint or compressive bandage is placed with the elbow at 90º.

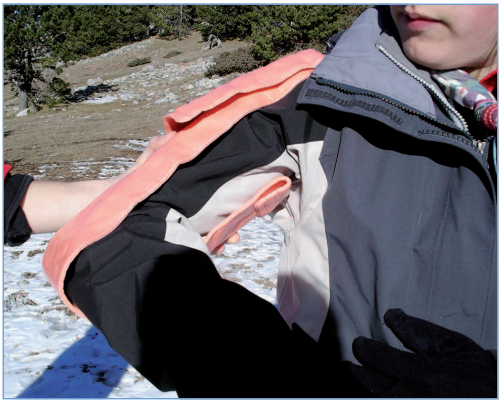


Figure 22.25. Arm immobilisation with mouldable splint.

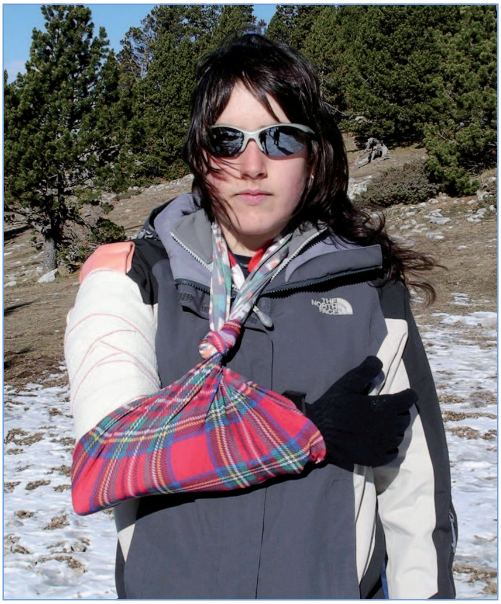


Figure 22.26. Arm immobilisation with mouldable splint and improvised sling.

Fractured clavicle

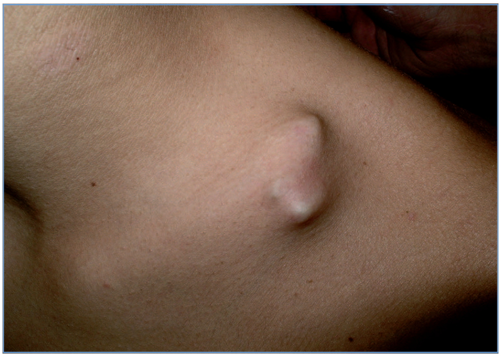


Figure 22.27. Complete fracture of clavicle.

Mechanism: direct blow or fall on the shoulder with the arm pressed against the body.

Exploration

- Inspection: the injured person has a shrunken shoulder and tends to hold their arm to avoid traction on the complete fracture site because of the weight of the arm. In the complete mid-third fracture (75% of complete clavicle fractures), a bony prominence is observed.
- Palpation: a painful osseous protrusion is observed when compressing the site of the fracture.
- Mobility: functional impairment due to pain.

Treatment

- Support the limb that is no longer supported by the collarbone, which is achieved with a sling.
- Avoid the anterior fluttering of the scapula around the thorax, an objective that is achieved by applying pressure to the anterior region of the shoulder by means of a figure-of-eight clavicular strap.
- Reduction: reduce a middle third fracture by pulling the shoulders backwards while pressing the knee against the injured person's dorsal spine.
- Immobilisation:
  - Complete mid-third fracture: sling or figure-of-eight bandage, checking every 3-4 days to avoid armpit sores, vascular or nerve compressions, or loosening of the bandage.

  - Complete external third fracture: sling with elbow-shoulder support strap.
  - Immobilisation time: 4-6 weeks.

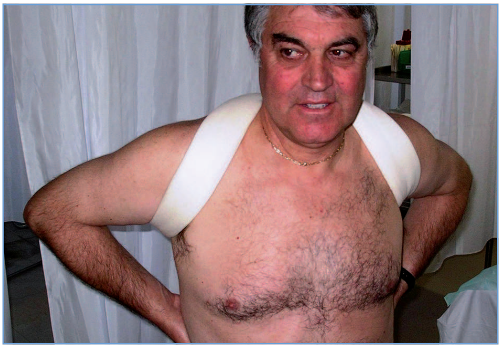


Figure 22.28. Figure-8 clavicle brace.

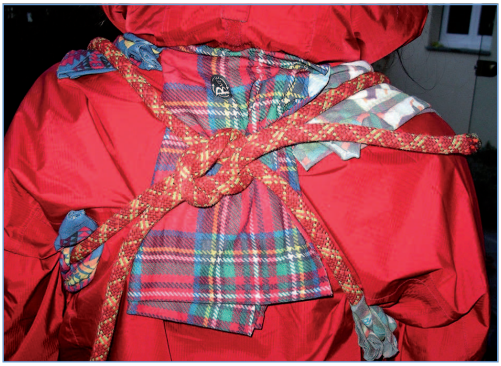


Figure 22.29. Figure-8 of clavicle brace improvised with cloths and rope.

Acromioclavicular dislocation

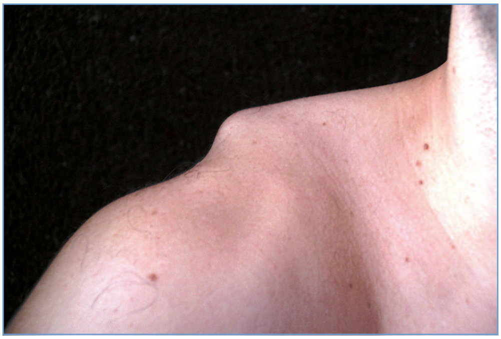


Figure 22.30. Acromioclavicular luxation.

Rupture or distension of the acromioclavicular and/or coracoclavicular ligaments. These lesions may be associated with complete fracture of the outer third of the clavicle.

Mechanism: falling over the top of the shoulder, forcing it downward as you roll over the shoulder.

Exploration

- Inspection:
  - Subluxation: normal appearance or small local inflammation of the acromion.
  - Luxation: ecchymosis and prominence of the distal end of the collarbone.
- Palpation: local pain on pressuring the distal end of the clavicle and the proximal end of the acromion. Piano key sign test/Spring test (ascent of the clavicle in its middle third) which consists of reducing the distal end of the clavicle by pressing downwards, becoming dislocated when the pressure is released.
- Mobility: pain and limitation of active arm abduction from 90° onwards.

Treatment

- Immobilisation: if there is no ligament rupture, a bandage with shoulder-elbow tapes, a Velpeau bandage or a sling is applied. Transfer to assess surgical treatment.
- Immobilisation time: sprain and subluxation, 4-6 weeks.

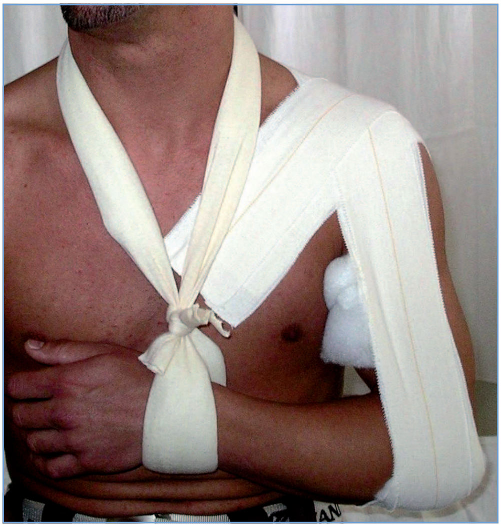


Figure 22.31. Immobilisation of acromioclavicular dislocation.

Glenohumeral dislocation

A loss of contact between the head of the humerus and the cavity of the scapula where the humerus is inserted. It is the most frequent dislocation (45-60% of all dislocations). 90% are anterior dislocations. 12% have lesions of the brachial plexus, and 9% of the axillary nerve; vascular lesions are rare.

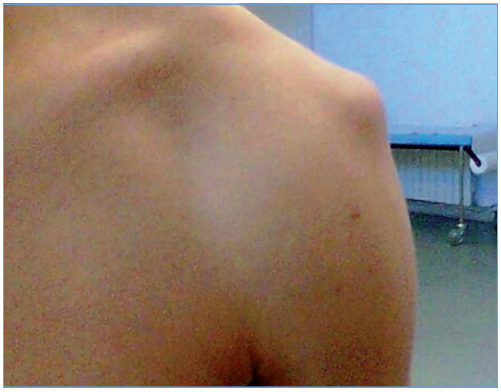


Figure 22.32. Glenohumeral dislocation.

Mechanism: blow on the shoulder from back to front or fall on the arm in abduction, extension and external rotation.

Exploration

- Inspection: loss of the osseous reliefs and the rounded shape of the shoulder. Slight abduction and internal rotation of the arm.
- Palpation: head of the humerus in anterior and inferior position to the clavicle. The glenoid cavity can be felt by pressing on the deltoid muscle. In case of doubt, the relative position of the head of the humerus and the glenoid cavity can be felt by touching the armpit.
- Mobility: functional impotence with rigid elasticity to passive mobilisation.

The risk of complete fracture-luxation is greater:[324]

- In people aged under 40: the mechanism involves a "substantial force" (e.g. car accident, assault, sports injuries, or a fall from a distance greater than the height of the victim).
- In people aged over 40: there is hematoma around the humerus, or this is the first dislocation.

Treatment[325]

The recommendation against reducing a dislocation of the shoulder before radiology is performed aims at preventing the worsening of a possible complete fracture. There is no evidence that attempting to reduce a shoulder luxation is a problem unless extreme force is applied in the attempt that could significantly worsen a hypothetical complete fracture. In addition, the reduction of dislocation allows for greater mobility of the victim, reduces pain, and creates a situation that allows for self-rescue.[326]

- Sling without binding the arm to the body (gloves and ski cap can be placed under the armpit) and transfer to hospital.
- Only attempt a reduction when the diagnosis is clear and there is no complete fracture associated with it, although a Canadian study of 92 skiers with this injury found that, when clinical data suspected dislocation without complete fracture, reduction prior to the practice of radiography –with the external rotation method– did not alter the subsequent management of these injured patients.[327-329]
  - External rotation method: effective in 82-90% of cases. Administer a relaxant (diazepam 10 mg sublingual). Apply traction and rotate the external arm very slowly until it reaches 90º. If pain or muscle contraction prevents this, general anaesthesia should be used. If it is not reduced, the shoulder is placed in adduction, so that the elbow begins to cross the chest, then the shoulder is internally rotated, bringing the hand of the injured person to the opposite shoulder.
  - Cunningham technique: massage the biceps into the mid-humeral area, with the patient's arm in adduction and the elbow flexed (resting on the doctor's shoulder). Simultaneously, the patient is asked to move the shoulder up and back to facilitate the relocation of the humeral head into the glenoid fossa.

Other techniques are Stimson maneouver, scapular manipulation, traction-countertraction, etc.

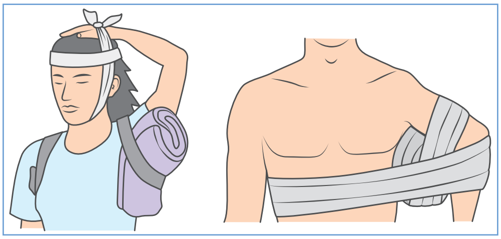


Figure 22.33 Reduction of a glenohumeral luxation.

- Check peripheral pulses and mobility of the trapezius muscle after reduction to rule out any injury to the circumflex nerve (tenderness in the area where military markings are placed) or to the axillary artery.
- If reduction fails after two attempts, immobilise and transfer to hospital to assess a reduction under anaesthesia.
- Immobilisation:
  - The arm should be lightly bound to the trunk with the elbow flexed, protecting the contact areas. One option is to make the Gilchrist bandage.
  - Immobilisation time: 3 weeks.

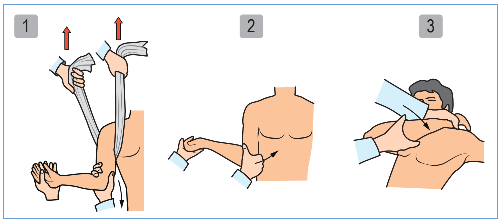


Figure 22.34. Immobilising a luxation of the shoulder with improvised sling and bandage under the arm.

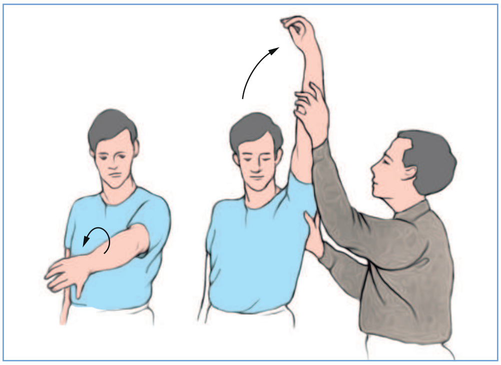


Figure 22.35. Neer test.

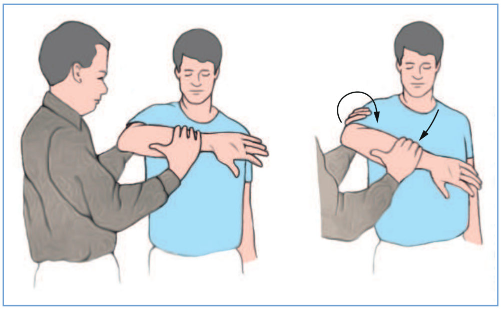


Figure 22.36. Hawkin's test.

Rotator cuff lesion

Table 22.9. Exploration of the shoulder

Yergason test	The patient's elbow is flexed to 90º and the forearm is outwardly pronated while the examiner resists forearm supination.
Neer test	The examiner lifts the internally rotated arm and flexes it passively while stabilising the patient's scapula with the other hand.
Hawkin's test	Shoulder and elbow flexed at 90°. Internal rotation.
Drop arm test	With the arm in a vertical, the patient is asked to lower it slowly to the side. The test is positive when the movement becomes irregular and the arm is quickly lowered from 100° of abduction.
Palpation test for rotator cuff tears	Patient with forearm flexion at 90º. The examiner makes a smooth internal and external rotation with one arm and the other feels under the acromion. With rotation you notice –compared to the other side– an abnormal prominence and an abnormal posterior furrow.

Table 22.10. Rotator cuff tendinitis[256]

Clinical findings	OR +	OR –
Yergason test	2.8	0.7
Neer test	1.3	0.4
Hawkin's test	1.4	0.3
Neer test and Hawkins test	1.6	0.1

Table 22.11. Rotator cuff tear[256]

Clinical findings	OR +	OR –
Drop arm test	5	
Age >59	3.2	
Age <40		0.1
Palpation for diagnosis of rotator cuff tears	10.2	0.1
Neer Test	1.5	0.3
Hawkin's Test	1.7	0.3

Treatment : sling, analgesia and ultrasound scan according to development.

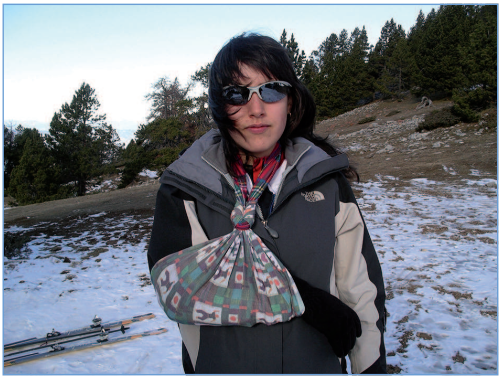


Figure 22.37. Improvised sling.

Elbow dislocation

The second most common luxation after the shoulder. It consists of the loss of contact of the joint veneers between the ulna with the trochlea of the humerus and the head of the radius with the condyle of the humerus. They are usually posterior and are associated with an extensive tearing of the joint capsule.

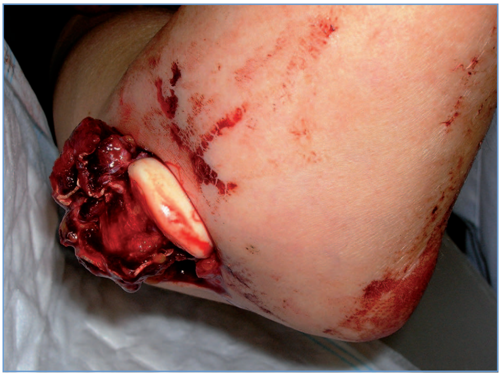


Figure 22.38. Elbow luxation with complete fracture.

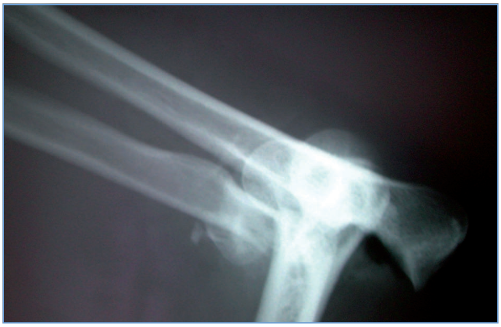


Figure 22.39. Radiology of elbow luxation with complete fracture.

Mechanism: fall on the palm of the hand and elbow in semi-flexion.

Exploration

- Inspection: the elbow is in semi-flexion at 45º with the sensation of a shortened arm. A deformity caused by the prominence of the olecranon can be observed when looking from behind.
- Palpation: step-shaped depression and exaggerated posterior prominence of the olecranon.
- The triangle formed by epicondyle-epithelial-olecranon with the elbow flexed is altered in elbow dislocations, while it is not altered in supracondylar complete fractures.
- We have to rule out:
  - Injury to the ulnar nerve: To do this, ask the patient to hold a sheet of paper between the 4th and 5th finger and the ulnar sensation is explored.
  - Injury to the median nerve: contraction and strength of the short thumb abductor are checked by palpating the muscle while the injured person tries to resist pressure on the thumb from a vertical position to the plane of the palm. Explore the sensitivity of the median nerve.
  - Injury to the humeral artery: feel the radial pulse.
- Mobility: the elastic stiffness makes it possible to differentiate between a disloca-

tion and a complete supracondylar elbow fracture, in which passive elbow mobility is possible.

Treatment

- Sling and transfer to hospital.
- If no associated fracture, try reduction. To do this, the forearm is gently pulled, making contraction of the arm and simultaneously increasing the arm flexion, while direct pressure is applied on the olecranon to avoid lateral displacements.
- After reduction, elbow is immobilised at 90º with splint or plaster from the root of the fingers to the middle third of the humerus.
- Immobilisation time: 3 weeks.

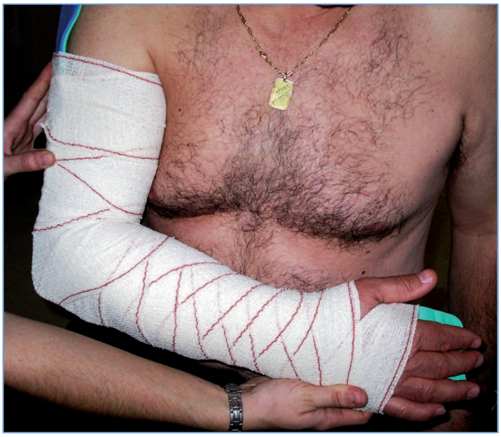


Figure 22.40. Immobilisation of the elbow with a mouldable splint.

Lower limb

Ankle injuries are usually the most frequent in mountainous areas.[330, 331]

Pelvic fracture

Exploration: the clinical examination has a sensitivity of 44-59% and a specificity of 71-99%.[203, 258]

- Inspection: ecchymosis on the iliac crests, pubis, lips, or scrotum. The discrepancy in limb length with external leg rotation without complete leg fracture suggests a complete pelvic fracture, as an unstable hemipelvis migrates in a cephalic direction due to muscle traction, and rotates externally secondary to the effect of gravity on an unstable hemipelvis.
- Palpation: pain on palpation of the pelvic ring. It is best not to explore pelvic mobility by gently pressing the anterior superior iliac spines and the symphysis of the pubic bone with the palms of the hands in an anterior-posterior direction, as this can trigger a retroperitoneal haemorrhage.

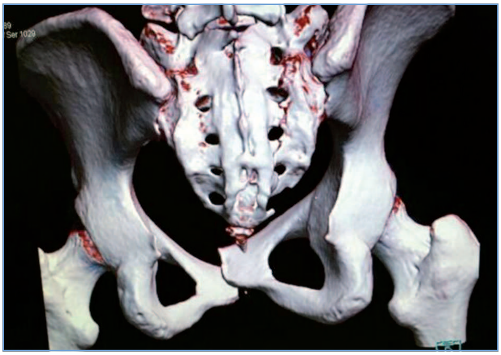


Figure 22.41. Unstable complete pelvic fracture.

Treatment

- Haemorrhage associated with complete pelvic fractures can occur directly from the fractured complete bone, from the pre-sacral venous plexus, or from the iliac vessels. The use of pelvic slings is effective in restoring the normal bone anatomy and may reduce the volume of bleeding, but it may also cause local tissue damage. The results of studies on the benefit of their use are heterogeneous, and more studies are needed to determine their efficacy in reducing mortality or bleeding in complete unstable pelvic fractures.[225] If a pelvic fracture (fall from a height with pelvic pain) is suspected, the pelvis (pelvic girdle) may be closed to reduce the pelvic volume and thus try to minimise the haemorrhage.[224]
- Immobilisation as in a complete fracture of the spine.

Fractures of the neck and upper third of the femur

Mechanism: leg rotation with fall on trochanter.

Exploration

- Inspection: shortening and external rotation of the leg.
- Palpation: elevation of trochanteric prominence and painful bitrochanteric compression. Groin pain.
- Mobility: functional impotence to active mobilisation. Limited and painful passive mobility.

Treatment

- Traction of the foot with the leg in extension, performing smooth de-rotation of the limb. Immobilisation (splint, vacuum mattress, etc.) and transfer to hospital.
- Medical service with adequate resources:
  - Cotton or cellulose bandage from the roots of the toes to the middle third of the thigh.
  - Placement of a Thomas splint covering up to the middle third of the thigh, holding the leg with a bandage. If this splint is not available, place a piece of wood across the axis of the leg on the heel of the shoe to prevent the foot from rotating.
  - Placing a pillow between the legs.
- Immobilisation can prevent a pulmonary fat embolism.
- Assess intravenous infusion of physiological serum to avoid a hypovolemic shock due to the large volume of blood in the fracture site (500-1,500 mL).
- Transfer to hospital.

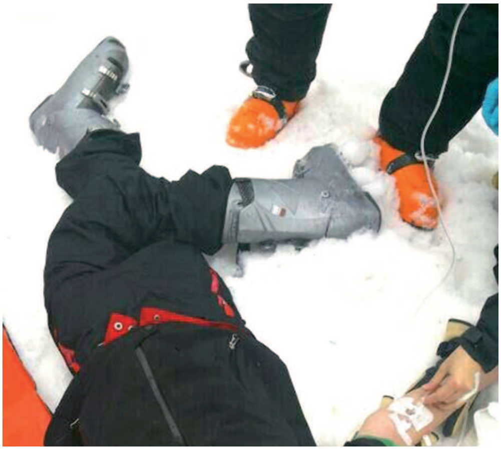


Figure 22.42. Complete fracture of femur.

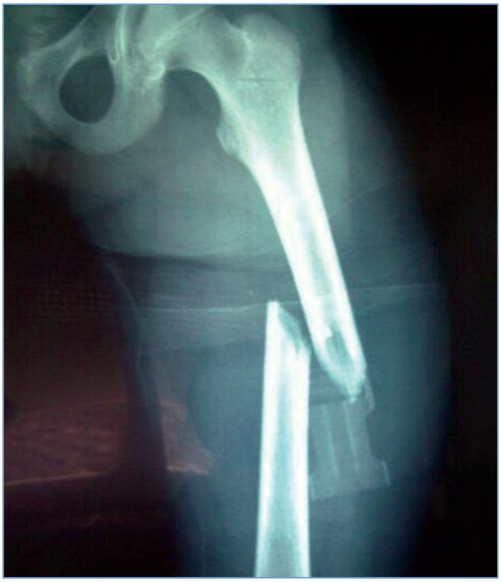


Figure 22.43. Radiology of complete fracture of femur.

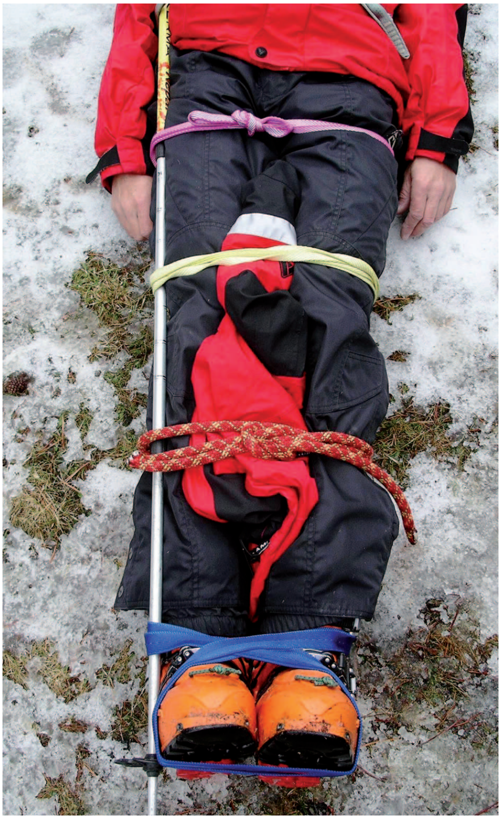


Figure 22.44. Immobilisation of femur and leg with a brace.

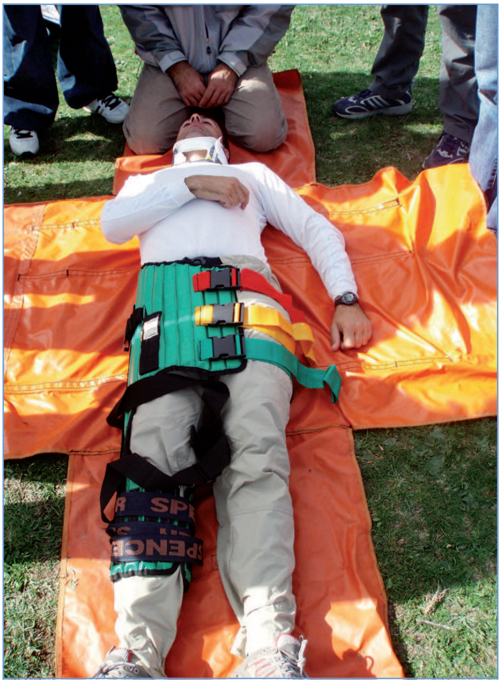


Figure 22.45. Immobilisation of femur with a Ferno KED.

Adductor tendinitis

Diagnosis

- Inguinal pain in sportspeople.
- Adduction against resistance is painful.

Treatment

- Rest and anti-inflammatories.

Knee exploration

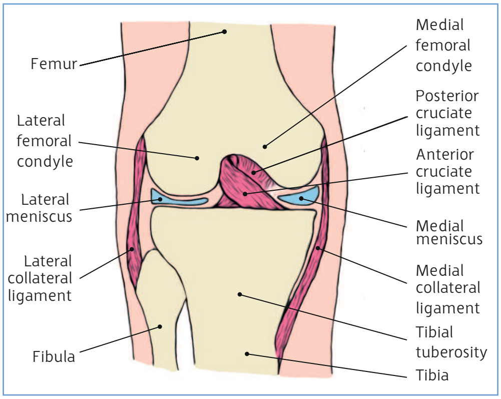

Femur
Lateral femoral condyle
Lateral meniscus
Lateral collateral ligament
Fibula
Medial femoral condyle
Posterior cruciate ligament
Anterior cruciate ligament
Medial meniscus
Medial collateral ligament
Tibial tuberosity
Tibia

Figure 22.46. Anatomy of the right knee.

Table 22.12. Knee examination

Patellar shock	The examiner presses on the prepatellar bursa with one hand and with the other presses the kneecap perpendicularly on the kneecap. If there is hemarthrosis, you can feel the impingement of the kneecap against the femur.
Lateral swelling of the kneecap	When performing the manoeuvre above, a tumefaction is observed on both sides of the patella.
Patellar apprehension	The patella is displaced laterally. If pain appears, it suggests an affection of the patellar cartilage.
Anterior drawer test	With the knee bent at 90°, the examiner sits on the ipsilateral foot and pulls the tibia in an anterior perpendicular direction. Any anterior displacement suggests a tear of the anterior cruciate ligament.
Lachman manoeuvre	Identical to the previous example but with the knee in a flexion of 20° and without leaning on the ipsilateral foot. Identical evaluation.
Pivot-shift sign	Starts with the limb in extension. A forced valgus is applied with one hand of the examiner and an internal rotation of the foot is made with the other and a progressive flexion of the knee is initiated. The manoeuvre is positive when from the age of 40 onwards a 'click' is noticed, which corresponds to a posterior subluxation of the tibia that translates into an injury of the anterior cruciate ligament.
Posterior drawer test	Identical manoeuvre to the anterior drawer test, but pressing the tibia perpendicular to the posterior. Any subsequent displacement results in a posterior cruciate ligament injury.
Forced valgus	With the knee bent at 10-20°, a forced valgus is caused, pressing the knee sideways. Any increase in the valgus suggests a ruptured inner lateral ligament of the knee.

Table 22.12. (Cont.) Knee examination

Mc Murray	With the knee bent and the foot in external rotation, the explorer places a hand on the inner interline. A slow extension of the knee is done. It is considered a positive signal if you notice a ‘click’. To explore the external meniscus, repeat the manoeuvre with the foot in internal rotation and feel the external interline.
Limited knee extension	There is an inability to perform a full extension of the knee.
Thessaly test	Is a dynamic reproduction of the load transmission. at the knee joint and is performed at 5° and 20° flexion. The examiner holds the patient’s hands with arms outstretched, while the patient stands with his or her feet flat on the floor. The patient then turns his or her knee and body, both internally and externally, three times, keeping the knee slightly bent (5°). The same procedure is then performed with the knee bent at 20°. The appearance of discomfort or blockage suggests meniscopathy. The test is first performed on the healthy knee, so that the patient learns what the test consists of and to recognise, in comparison, a possible positive result on the symptomatic knee.

Table 22.13. Findings on ligament and meniscal injuries[256]

			Probability of injury when the finding is:	
Clinical finding	**OR +**	**OR −**	**present**	**absent**
Knee pain injury (10% pre-test probability)				
Internal meniscus injury. Thessaly test (5º flexion)[3]	16.5	0.35	64.7%	3.7%
External meniscus injury. Thessaly test (5º flexion)[3]	9	0.21	50%	2.3%
Internal meniscus injury. Thessaly test (20º flexion)[3]	29.7	0.11	76.7%	1.2%
External meniscus injury. Thessaly test (20º flexion)	23	0.08	71.9%	0.9%
Meniscus injury. McMurray test	8.2-17.3	0.49-0.8	65.8%	5.2%
Meniscus injury: inability to perform a full extension of the knee	3.2	0.7		
ACL injury: anterior drawer	3.7-11.5	0.5-0.6	29.1%	6.3%
ACL injury: Lachman	12.4-17	0.14-0.2	57.9%	1.5%
ACL injury: pivot test	8-20.3	0.4	69.3%	4.3%
PCL injury: posterior drawer	97.8	0.1		
LLI injury: internal joint line opening with flexion between 0 and 20º	146.5	0.2		

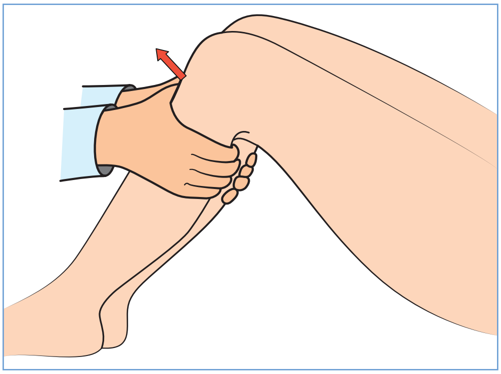


Figure 22.47. Anterior drawer.

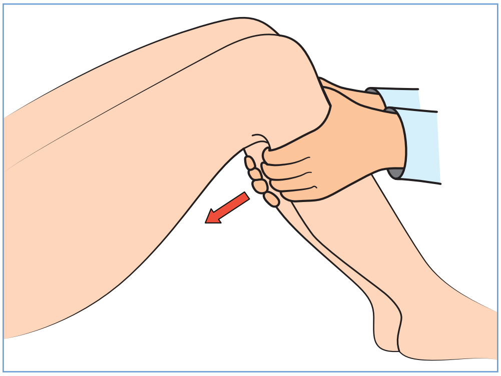


Figure 22.48. Posterior drawer.

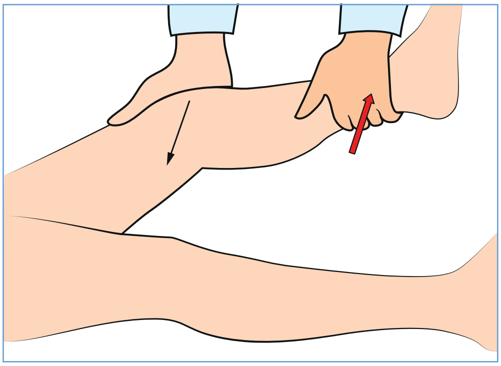


Figure 22.49. Forced valgus.

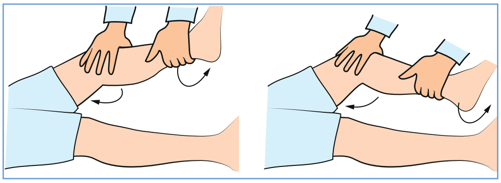


Figure 22.50. McMurray sign.

Figure 22.51. Alpine skiing 2.

Knee ligament lesions

Is a distension or rupture of one or more joint ligaments, often associated with meniscal or muscular injuries.

Prevention

Injuries to the knee ligaments are the most frequent in skiing and can be prevented by properly adjusting the bindings.

Mechanism

The lateral ligaments are injured by a forced valgus or varus of the knee. If the knee is in full extension, injury to the cruciate ligaments and posterior capsular ligaments may also occur.

The cruciate ligaments are injured by trauma resulting in antepulsion (anterior cruciate ligament) or retropulsion (posterior cruciate ligament) of the tibia.

Exploration

The examination should be bilateral to compare with the healthy side and determine if there is ligament laxity.

- Inspection: inflammation may be present.
- Palpation: pain in the insertion and/or trajectory of the lateral ligaments of the knee.
- Mobility: very limited by pain and joint effusion.
- Exploratory manoeuvres: see Table 22.12.
- The tumefaction and the intensity of the pain are not related to the severity of the injury, mild sprains are generally more painful.

- When instability is found, it is necessary to compare it with the healthy knee.
- Explore the peripheral pulses and the external popliteal sciatic nerve (foot extension).

Treatment

- Immobilisation with compressive bandage from the upper third of the thigh to the ankle.
- Transfer to hospital.
- Immobilisation time: 2-3 weeks in mild cases. Sports activity should be avoided for two months with mild sprains, four months with complete lateral ligament tears and more than five months with anterior cruciate ligament tears.

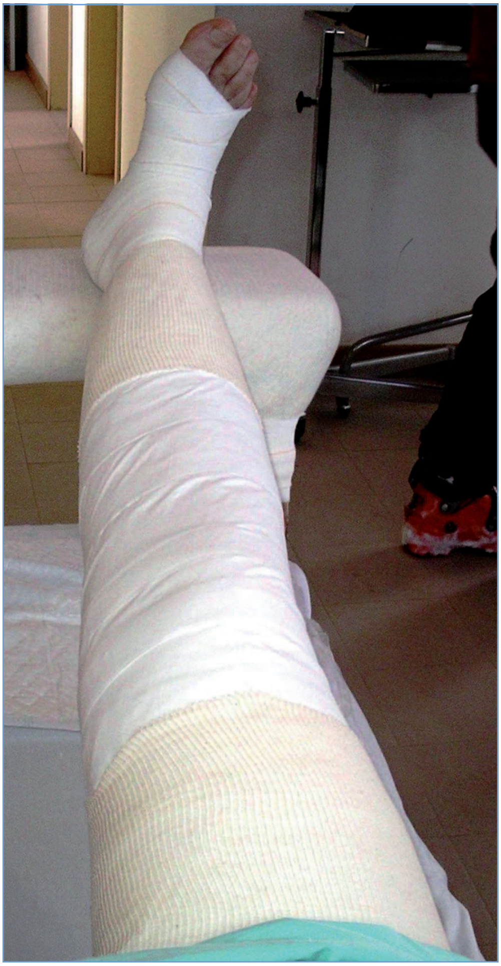


Figure 22.52. Compressive leg bandage 1.

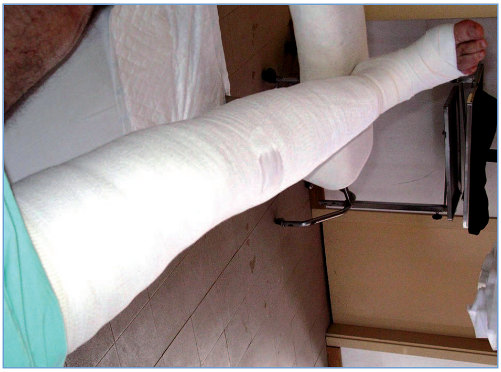


Figure 22.53. Compressive leg bandage 2.

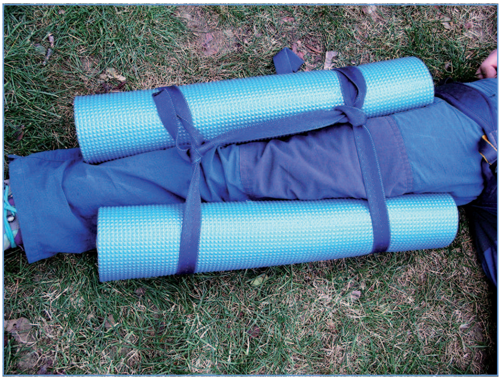


Figure 22.54. Immobilisation with a mat.

Meniscal lesions of the knee

Mechanism: occurs during flexo-extension of the knee combined with internal or external rotation of the femur, with the leg firmly seated on the floor.

Exploration[332]

- Anamnesis: intense pain occurs at the moment of injury, with a perception of crackling and a sensation of joint displacement, then the pain becomes more diffuse.
- Inspection: the inflammation is slow to appear.
- Palpation: If there is joint effusion, patellations are observed. Pain in the interline joints when rotating the foot exploring with the knee bent at 90°.
- Mobility: if there is no joint effusion, there is complete recovery within a few hours.
- Exploratory manoeuvres: see Table 22.13.

Treatment

- Immobilisation with compressive bandage from the upper third of the thigh to the ankle.
- Transfer to hospital.
- If there is significant joint effusion, it can be evacuated by joint puncture.

Knee fracture

Diagnostic orientation

The Ottawa rules recommend taking X-rays if any of the following 5 elements are present: 1) age ≥ 55 years; 2) isolated pain in the kneecap; 3) pain in the fibula head; 4) inability to bend the knee to 90 degrees; 5) inability to support weight immediately and in the accident and emergency department (limping is acceptable).

The Pittsburgh rules recommend taking X-rays if the mechanism of the injury is a closed trauma or fall and either: 1) the age is <12 years old or >50 years old, or 2) the patient cannot complete four steps while bearing weight in the accident and emergency department.[333]

The Pittsburgh rules have a similar sensitivity to the Ottawa rules (99%) with a significantly higher specificity (Pittsburgh 60% vs Ottawa 27%). The Pittsburgh rules may reduce X-rays without lowering sensitivity.

Table 22.14. Complete knee fracture[256]

Clinical findings	OR +	OR –
Ottawa Rules[334]		
Age over 55 years old.	3	
Isolated pain in the kneecap (no bone pain anywhere other than the kneecap).	2.2	
Pain in the head of the fibula.	3.4	0.9
Impossibility of bending at 60°.	4.7	0.6
Inability to support body weight immediately after trauma and in the emergency department (4 steps; inability to pass weight alternately to the other limb on two occasions regardless of limping).	3.6	0.6
Ottawa Rules absent	**1.7**	**0.1**

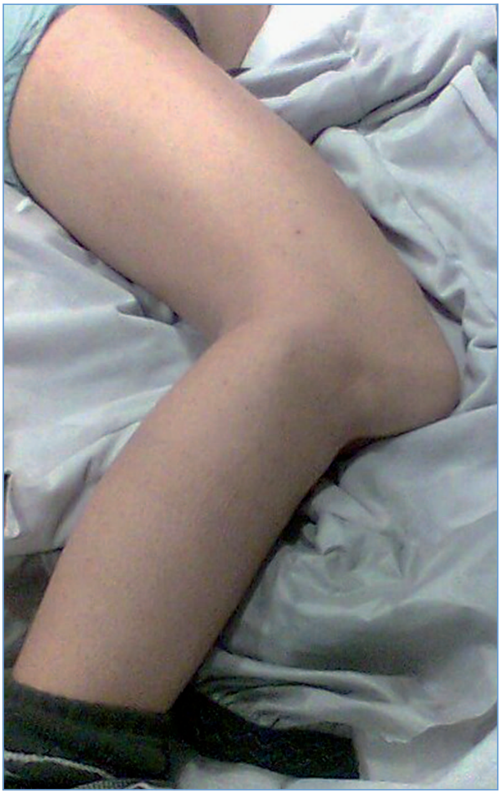


Figure 22.55. Knee dislocation.

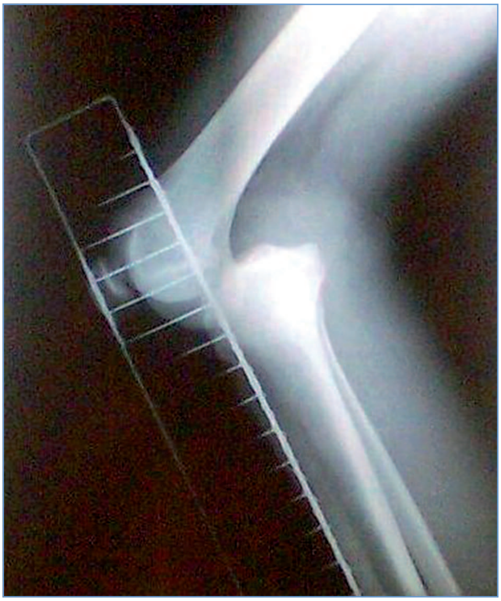


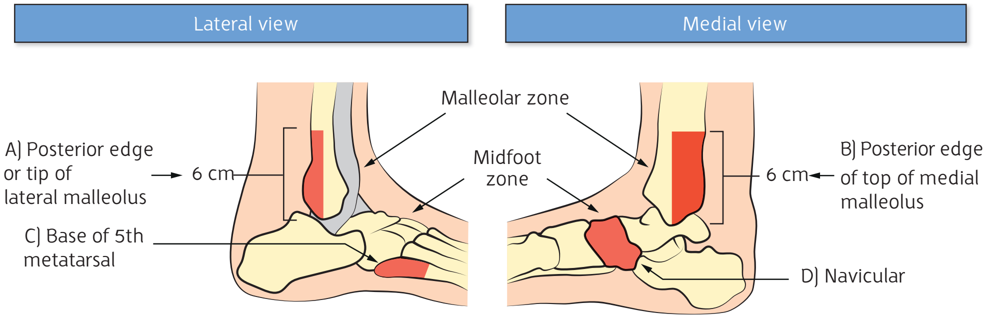
Figure 22.56. Knee dislocation. Radiology.

Fracture of tibia and fibula

Diagnostic orientation

- Complete fibula fracture: local pain, tumefaction, discreet functional impotence that does not prevent walking.
- Complete tibial fracture: deformity, no walking.

Ottawa rules for suspecting complete ankle or foot fracture:[335-338] the test has a positive predictive value (when the test is positive the patient has a complete fracture) of 17% and a negative predictive value (when the test is negative the patient has no complete fracture) of almost 100%.


Lateral view
Medial view
Malleolar zone
A) Posterior edge or tip of lateral malleolus
6 cm
C) Base of 5th metatarsal
Midfoot zone
B) Posterior edge of top of medial malleolus
6 cm
D) Navicular

A An ankle X-ray series is required if there is pain in the malleolar zone and any of these findings:

1. Bone tenderness experienced on palpation of the posterior edge (6 cm) or inferior tip of the lateral malleolus.
2. Bone tenderness experienced on palpation of the posterior edge (6 cm) or inferior tip of the medial malleolus.
3. Inability to bear weight (for four steps without help) immediately after the injury and in the accident and emergency department.

B A foot x-ray series is required if there is pain in the midfoot zone and any of these findings:

1. Bone tenderness on palpation of base of 5th metatarsal.
2. Bone tenderness on palpation of navicular bone.
3. Inability to bear weight (for four steps without help) immediately after the injury and in the accident and emergency department.

Figure 22.57. Ottawa rules for suspecting complete ankle or foot fracture.

Table 22.15. Diagnostic utility of the Ottawa rules in patients with an ankle trauma for the presence of a complete osseous fracture[256]

Finding	OR + combined	OR – combined
Pressure tenderness in posterior lateral malleolus	2.4	0.4
Pain over medial malleolus	4.8	0.6
Inability to stand up after trauma	2.6	0.5
Inability to walk 4 steps	2.5	0.3
Ottawa ankle rules (1+2+3+4)	1.5	0.1

Table 22.16. Diagnostic utility of the Ottawa rules in patients with foot trauma for the presence of a complete fracture in the central area of the foot[339]

Finding	OR + combined	OR – combined
Pain at the base of the 5th metatarsal	2.9	0.1
Aching at pressure of the navicular bone	0.4	-
Inability to stand up immediately	-	-
Inability to walk 4 steps	-	-
Ottawa foot rules (1+2+3+4)	2.1	0.1

Treatment

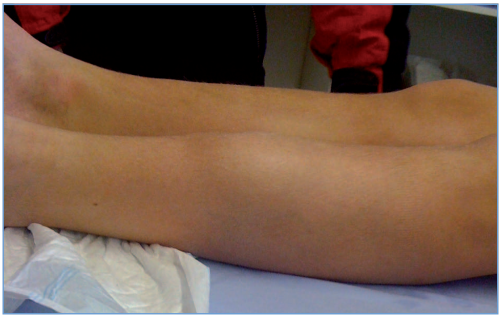


Figure 22.58. Complete fracture of tibia.

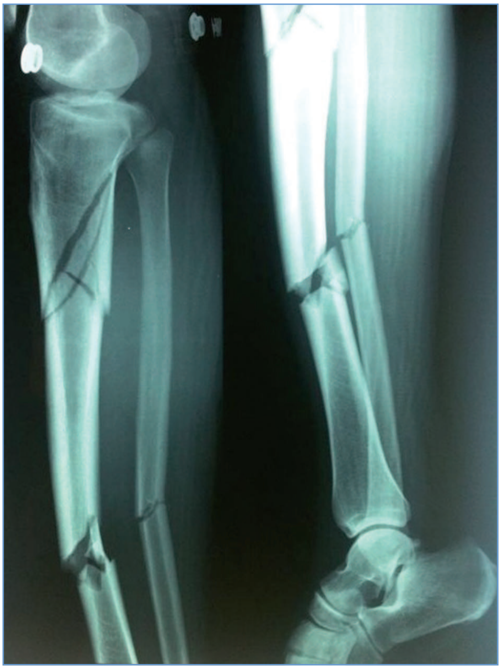


Figure 22.59. Fractured tib-fib. Radiology.

- If the fractures are not displaced, immobilise them with the knee slightly bent. If they are displaced, temporarily immobilise them in the most comfortable position for the patient.
- Transfer to hospital.

Ankle sprain

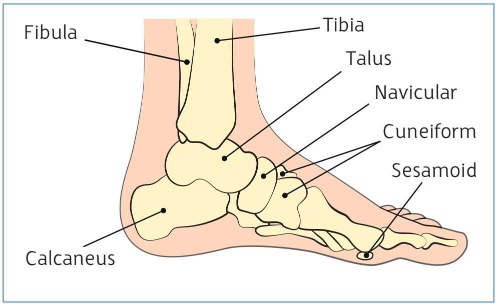


Figure 22.60. Anatomy of the foot.

This is a distension of the capsule-ligament complex of the ankle, usually affecting the external ligaments.[340]

Mechanism: ankle forced bending.

Classification

- Grade I or mild: strain without ligament rupture. Intense pain appears after an asymptomatic period (cooling), there is little tumefaction. Functional impairment is variable.
- Grade II or moderate: stretching that exceeds the limit of elasticity of the ligament and produces a rupture of fibre bundles of a ligament (partial rupture). There is soft tissue tumefaction in the first few hours, then joint tumefaction and late hematoma.

- Grade III or severe: complete ligament rupture. Very intense instantaneous pain appears with immediate bruising; pain decreases within a few minutes and sometimes allows for ambulation. The injured person notices a tear in more than 50% of the cases.

Exploration

- Palpation: associated fractures should be ruled out.
- Mobility: variable limitation.
- Exploratory manoeuvres:
  - Varus gapping: indicates lateral instability.
  - Anterior drawer: indicates antero-posterior instability.

Treatment **(A)**[304]

- Grade I:
  - Protection.
  - Localised cold: 15-20 minute sessions every 4-6 hours; wrap the ice or snow in cloth to avoid cold injury.
  - Compression bandage with an elastic bandage (never stiff) from the root of the toes to below the knee for 1-3 weeks.
  - Avoid sports activity in the post-trauma period, then train with optimal load.
- Grade II:
  - Localised cold: 15-20 minute sessions every 4-6 hours; wrap the ice or snow in cloth to avoid cold injury.
  - Raised foot and walking with no load (walking sticks) for 48-72 hours.
  - Anti-inflammatory drugs.
  - Immobilisation with plaster or taping for 3 weeks allowing ambulation.
  - Avoid sports activity for 2 months.
- Grade III:
  - Localised cold: 15-20 minute sessions every 4-6 hours; wrap the ice or snow in cloth to avoid cold injury.
  - Anti-inflammatory drugs.
  - Immobilisation with plaster or taping for 4 weeks and taping for 10 days.
  - Possible surgical indication.

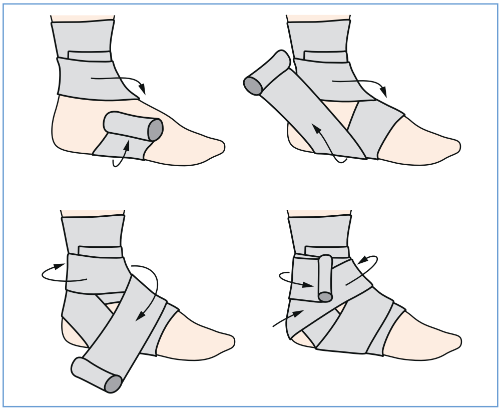


Figure 22.61. Ankle bandage.

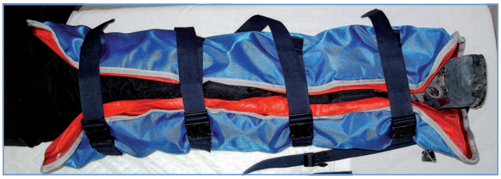


Figure 22.62. Immobilisation with a vaccum splint.

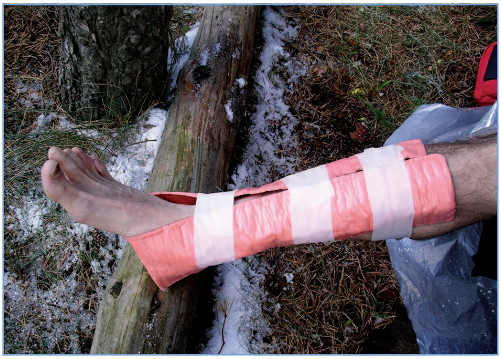


Figure 22.63. Immobilisation of the ankle with a mouldable splint.

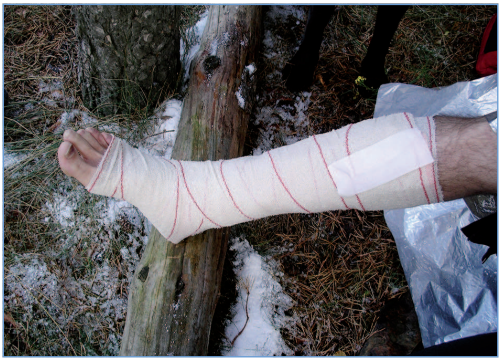


Figure 22.64. Functional ankle bandage 1.

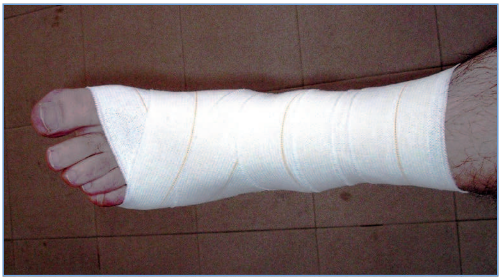


Figure 22.65. Functional ankle bandage 2.

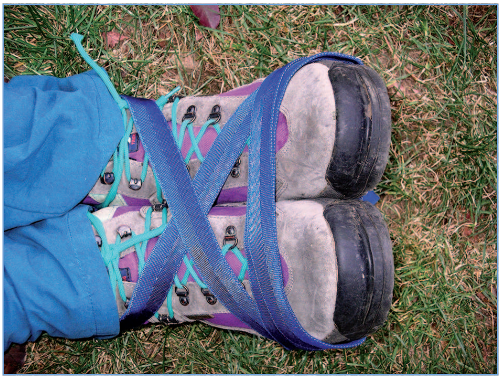


Figure 22.66. Improvised ankle immobilisation.

Fracture of the talus and calcaneus

Are frequent in climbing. Complete astragalus fractures often result in avascular necrosis, resulting in a secondary osteoarthritis that can limit the ability to practice sports.

Treatment: immobilisation and transfer to hospital.

Metatarsal fracture

Seriousness and prognosis depend on the alignment of the fragments and the number of metatarsals injured. Complete isolated fractures of the 1st and 5th metatarsals are the ones that cause the most functional alterations in foot support.

Mechanism

- A direct impact.
- Fatigue fracture due to prolonged exertion. The complete fractures typical of prolonged walking or running are observed in the diaphysis of the 2nd and 3rd metatarsals; sometimes the fracture line is not visible until 2-3 weeks after the onset of pain and dorsal swelling.
- Overload fracture by twisting your ankle or improperly supporting your foot. Examination of an ankle sprain should include pressuring with your fingers the base of the 5th metatarsal to rule out a complete fracture.

Exploration

- Inspection: local oedema, sometimes with hematoma.
- Palpation: local pain under pressure and when carrying the weight of the body on the foot.
- Mobility: local pain.

Treatment

- Prehospital:
  - If there is selective pain at the base of the 5th metatarsal: elastic adhesive bandage.
  - Rest of metatarsals: compressive bandage.
  - Elevate the foot.
- Medical service: immobilisation with a boot cast from the roots of the toes to the tibial plateau, with the neutral foot and ankle at right angles. If the fragments are not aligned, they should be reduced by osteosynthesis with a needle.
- Immobilisation time: 4-6 weeks.

Fracture of the phalanges of the feet

Mechanism: a direct impact.

Exploration

- Inspection: local oedema, late haematoma. Complete fractures of the distal phalanges may be associated with subungual haematoma.
- Palpation: pain.
- Mobility: active and passive functional impairment.

Treatment

- Immobilisation: attach the complete fractured finger to the healthy adjacent finger with adhesive tape, first placing a gauze between the fingers to avoid skin maceration, and leaving the nail bed exposed to control proper blood circulation.

- If there is a subungual haematoma, evacuate it by piercing the nail with an incandescent paperclip.
- If the fragments are not aligned, reduce them by osteosynthesis with a needle.
- Immobilisation time: 20-30 days, replacing the bandage every week.
- Early ambulation is recommended.

23 SOFT TISSUE INJURY

Soft tissue injuries are those that do not affect bones or ligaments. The most common in the mountains are bruises, abrasions, lacerations and blisters.

The objectives in their management are:

- Control bleeding.
- Minimising risk of infection.
- Promoting healing.
- Reducing discomfort.
- Minimising loss of function.
- Maintaining aesthetics.

The wounds may be

- Clean.
- Dirty: when they are in an area with a high bacterial rate (e.g. armpit) or when more than 6 hours have passed since they were first produced.
- Contaminated.

CONTUSIONS OR BRUISES

Bruises are crush injuries that cause bleeding into damaged tissue. They are usually caused by direct blows to the surface of the skin. Bleeding under the skin gives them a bluish colour (haematoma).

Treatment: rest, apply localised cold for 20 minutes wrapped in a cloth to avoid cold injury **(B)**, local compression and elevation of the limb to reduce the swelling and pain. Ibuprofen analgesia can be administered at a dose of 400-600 mg every 8-12 hours.

BLISTERS

The blisters are usually caused by the boots rubbing.

Prevention

- Fit the boots correctly
- If there are rubbing points, it is recommended to apply 3-4 layers of well-fitting, wrinkle-free fabric tape that goes well beyond the friction zone.
- Sprinkle the feet with talcum powder or apply petroleum jelly.
- Wear tubular socks or two pairs of socks.
- If pain occurs while walking, it is best to stop and apply tape before the blister appears.

Treatment

Once the blister has appeared, it can be emptied with a disinfected needle and covered with a dressing, after cleaning the surface with povidone-iodine.

If the skin covering the blister has peeled off, treat it with a non-adhesive dressing, like a scratch.

If friction in the area is avoided, healing is rapid. Leave the blister exposed for as long as possible to dry and heal.

SUBUNGUAL HEMATOMA

A subungual haematoma can be emptied by making a small hole through the nail. It can

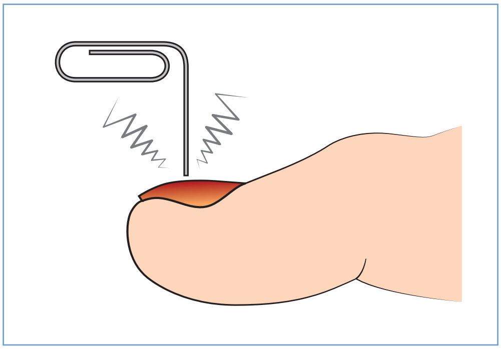


Figure 23.1. Subungual haematoma drainage.

be done with a sterile intramuscular needle or with a paperclip that has a glowing tipped heated by a flame. This procedure is painless, as long as you take the precaution of moving slowly so as not to touch the nail matrix when piercing the nail that is sensitive.

INGROWN TOENAILS

Ingrown toenails occur when the edge of the toenail grows into the surrounding soft tissue, resulting in painful inflammation and infection.

Prevention

- Footwear should be of adequate length and width, as continuous pressure on the nail may result in ingrowth.
- The toenails should be cut straight, preventing the lateral margins from penetrating the skin.
- Changing socks, airing and drying the feet, eliminate the excess of humidity by the sweat, a factor that triggers this pathology.

Treatment

To treat the ingrown nail, soak the foot in warm water for about 20 minutes, and when the nail is soft and flexible, insert a cotton ball with a drop of povidone-iodine underneath its rim with tweezers to lift it from the soft tissue. This procedure is continued until the nail is large enough to be cut straight.

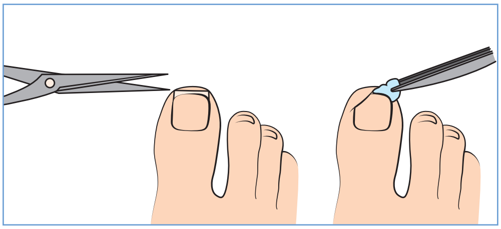


Figure 23.2. Ingrown nail treatment.

PUNCTURE WOUNDS WITH EMBEDDED OBJECT

If the injured person has an object piercing them (e.g. ice axe in the abdomen), it must be handled with the utmost caution in order to remove it without causing further tissue tears. If in doubt, do not remove it and secured it so that the injury does not worsen with movement. Cover the wound with a sterile, compressive dressing and give analgesia until arrival at the hospital.

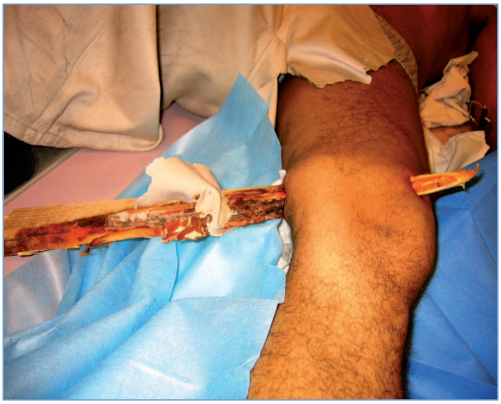


Figure 23.3. Wound due to penetrating object.

ABRASIONS, LACERATIONS, AND WOUNDS THAT DO NOT REQUIRE SUTURING

Abrasions are scratches in which the outermost layer of skin has been detached. They are often caused by friction with snow or grass during falls, or by friction with rope during securing. As the top layer of skin disappears, numerous blood capillaries are exposed and the dirt that penetrates the skin increases the likelihood of infection if the wound is not cleaned properly.

A particular case is chafing or rubbing in areas with skin folds, such as the groin and inner thighs, armpits or in sub-mammary folds and nipples. They are not serious injuries but they are very annoying.

Lacerations result from tearing the tissues with a sharp or pointed object, giving the wound the appearance of a cavity with jagged edges.

The aim of wound repair is to achieve haemostasis, prevent infection, restore tissue function and achieve optimal cosmetic results.

Treatment of wounds that do not require any suturing

The treatment of these injuries consists of: [341, 342]

- Haemostasis: control the haemorrhaging.
- Washing wounds: avoid infection by washing the wound thoroughly. Before cleaning the wound, wash your hands thoroughly with plenty of soap and water. If sterile gloves are available, they should be worn. Wash the wound with plenty of clean water or saline solution for five minutes, or until no dirt is observed[343] **(B).** If a large syringe is available, water can be sprayed over the wound to better remove dirt. If necrotic tissue remains, remove it with tweezers or trim it with sterile scissors. Dirty wounds can be disinfected with chlorhexidine in 2% aqueous solution or 10% povidone-iodine, leaving the product on for 3-5 minutes. It is not recommended to rub wounds, except for abrasion wounds where brushing with 10 to 50% povidone-iodine is essential to remove impacted tissue debris. It should be noted that, although povidone iodine is useful when cleaning and disinfecting wounds, it is not recommended to apply povidone iodine as a maintenance cure for abrasions, as it can damage tissue and delay healing; silver sulfadiazine is the recommended cure in these cases, as it helps to remove remains and minimise tattooing. The use of merbromin is also not recommended, as it makes assessing and cleaning difficult at the critical moment, and delays healing.
- Foreign body removal: wounds should be carefully assessed, removing any foreign body debris that would increase the risk of infection.
- Debridement: removal of non-viable tissue in contaminated wounds is recommended to reduce the risk of tissue necrosis, the period of inflammation and the risk of infection.
- Healing of wounds:
  - If the wound is small and does not bleed and the environment is clean, it may be left uncovered.
  - If the wound is not that small but it is clean, it may be covered with a gauze dressing that is bandaged or taped. Vaseline gauze may be placed in contact with the wound to prevent the gauze from sticking. Change the dressing daily to check that the wound has not become infected. New materials can be used, such as semi-permeable films or hydrocolloid dressings that are left in place for a week.
  - On chafes, after cleaning and drying, you can apply a healing ointment with around 25% zinc and lanoline (Desitin®, Lasar®, etc.) and cover the area with gauze to prevent further rubbing.
  - Honey dressings as an accompaniment to compression do not significantly increase the healing of venous leg ulcers.[344]
- Tetanus prophylaxis if necessary. Remember that after the initial immunisation, a booster dose should be administered every 10 years.

Regarding antibiotic use, prophylactic therapy is not recommended but any warning signs suggesting a wound infection should be taken into account.

During the first 3 days after the accident, the wound will show typical signs of inflammation, coinciding with the signs of infection: pain, heat, redness, tumefaction and limitation of movement. Suspect wound infection when these signs do not decrease or increase after the third day, fever or pus appears, and the regional lymph nodes become enlarged and painful (in all three cases, suspect infection of the wound).

Treat complete open fractures and mammalian bite wounds with antibiotics **(B).**

Clean wounds don't usually get infected. If the wound is infected, it should be opened for drainage by placing a moist gauze impregnated with 50% povidone-iodine for the first day and changing it every 6-8 hours. From the first day, continue with moist gauze with saline solution every 8-12 hours until the wound looks clean (usually 1 or 2 more days). Antibiotic therapy is also given for infected wounds.

TREATMENT OF WOUNDS THAT REQUIRE SUTURING[345 342]

The following steps are followed:

- Bleeding control through adequate compression.
- Clean the wounds with plenty of water. Saline serum has not shown any advantages over water.[346] It is possible that when the clots are removed, vascular mouths may reopen and re-bleeding may occur, which will require the application of a compressive bandage or haemostatic stitches, but on a cleaner wound.
- Wound assessment and foreign body removal: in a deep wound, it is important to evaluate movement, circulation and sensitivity to rule out muscle, tendon, vascular or nerve involvement.
- Debridement of devitalised tissues.
- Suturing the wounds: suturing a deep wound is not appropriate if it is not well explored to rule out arterial and nerve damage, which may go unnoticed outside of a surgical setting.
- Conservative treatment is as effective as suturing on hand lacerations smaller than 2 centimetres.
- Assessment of antibiotic therapy: clean wounds are rarely infected and prophylactic antibiotics are not recommended, but the appearance of warning signs should be taken into account.

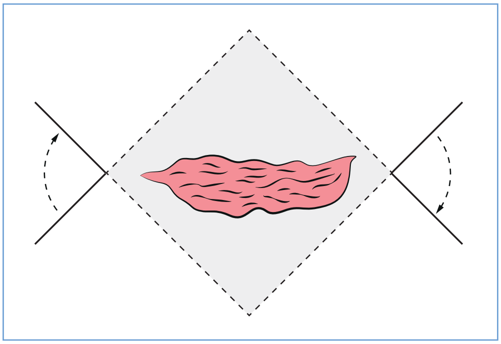


Figure 23.4. Local anaesthesia technique for sutures.

Wounds with low skin tension (face, chin, back of the hands) can be treated by joining the edges of the wound with strips of adhesive paper with the same aesthetic, dehiscence and infection results as with sutures **(A)**.[347]

The rest are stapled or sutured together **(B)**:

- If the wound is clean and has less than 6-12 hours of evolution, it is sutured directly. If it takes more than six hours, you will have to be treated by expert personnel who will decide whether to apply sutures or not (facial wounds can be sutured even after 24 hours without increasing the risk of infection too much), and if so trim the edges of the wound before suturing. Wounds at high risk of infection should be sutured within the first 6 hours.
- Local anaesthesia: a fine needle (the bevel of the needle in a horizontal position with respect to the skin) is used and, after aspiration to ensure that the needle is not inside a vessel, anaesthetic infiltrates, causing a small dermal heap. “Rhombus” anaesthetic infiltration: with two beads at both ends, the needle is inserted through one of them, small amounts of anaesthetic are injected as it is advanced and more is injected when it is removed. When you reach the point of entry and without removing the needle, you change its direction to infiltrate the other side. Then the technique is repeated from the other vertex.
- Exploration of the wound.
- Suture: see technique below.

Table 22.1. Choice of suture thread

Body zone	Kind of thread
Face	silk 5-6/0
Scalp	silk 2-5/0
Thorax, back	silk 3-4/0
Limbs	silk 4-5/0
Subcutaneous cellular tissue	vicryl or dexon 3-4/0

- Suture technique
  - Close the deep planes first so as not to leave free cavities where bruises that could become infected would accumulate.
  - Then, suture the skin with the fewest number of stitches to ensure a non-de-

hiscent wound. The knot should be tightened until the wound lips begin to touch.
  - A knot is then made on each side of the wound to avoid putting excessive pressure on the first one, as this could result in an area of ischemia and infection.

Table 22.2. Time for stitch removal

Body zone	Time for stitch removal
Face and nose	3-5 days
Scalp	7- 10 days
Upper limbs	7-10 days
Lower limbs	10-14 days
Hands or feet	10-14 days
Palms of the hand or soles of the feet	14-21 days
Trunk	10-14 days

- Cure: putting on a dressing and bandage to keep it dry for 12 hours does not increase the risk of infection if it gets wet after that time.
- Tetanus prophylaxis if necessary.
- Assessment of antibiotic therapy: clean wounds are rarely infected and prophylactic antibiotic therapy is not recommended, but the appearance of warning signs in wound progression should be taken into account.
- Check after 24 hours.

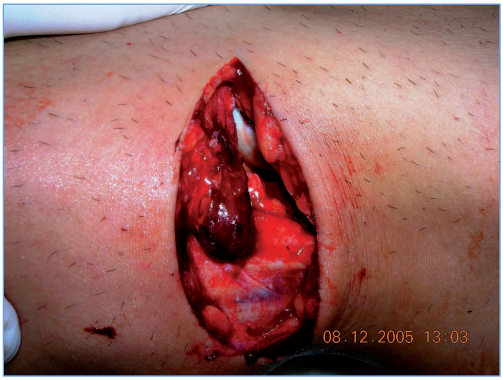


Figure 23.5. Wound by ski edge.

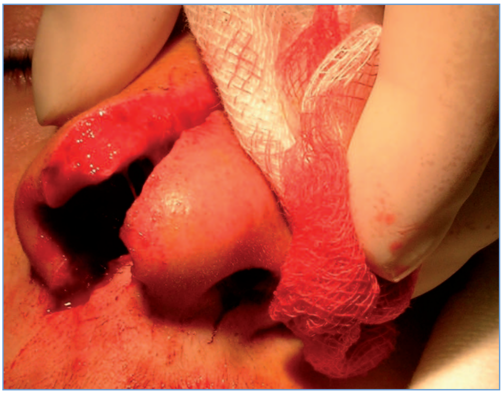


Figure 23.6. Nose wound by ski edge.

DRESSINGS AND BANDAGES

A bandage is usually made up of:

- An inner layer of sterile vaselinised gauze (Tulgrasum®, Linitul®) so that it does not adhere to the wound.
- A central layer or dressing made up of sterile gauze that has the purpose of:
  - avoiding contamination of the wound,
  - absorbing the fluid that exudes from the wound,
  - keeping adjacent skin dry,
  - applying pressure to the wound to control bleeding and tumefaction,
  - protecting the wound from impacts.
- An external bandage that serves to:
  - keep the dressing in place,
  - keep the dressing from getting wet,
  - apply pressure to control bleeding and tumefaction,
  - splint and immobilise if necessary.

Table 23.3. Width of bandages

Body zone	Width (cm)
Fingers	2.5
Upper limb	10
Lower limb	15
Thorax	20

24 BURNS AND SCALDING INJURIES

BURNS

The skin has multiple functions, among which the following stand out:

- Temperature regulation and prevention of liquid loss by evaporation.
- Barrier of protection against infection.
- It has sensory receptors that give information about the environment.

A large burn compromises these functions. The skin is made up of three layers:

- Epidermis: a more superficial layer formed by squamous cells.
- Dermis: middle layer, formed by connective tissue, containing the blood capillaries that nourish the skin and nerve endings.
- Hypodermis: the innermost layer, formed by connective tissue and fat.

Classification

Depending on the depth, the burn may be first, second or third degree:

First degree

- It only affects the epidermis.
- Skin integrity.
- Erythema.
- The tissue becomes white under pressure.
- Pain.
- Not counted when calculating burn extent.
- They heal on their own.

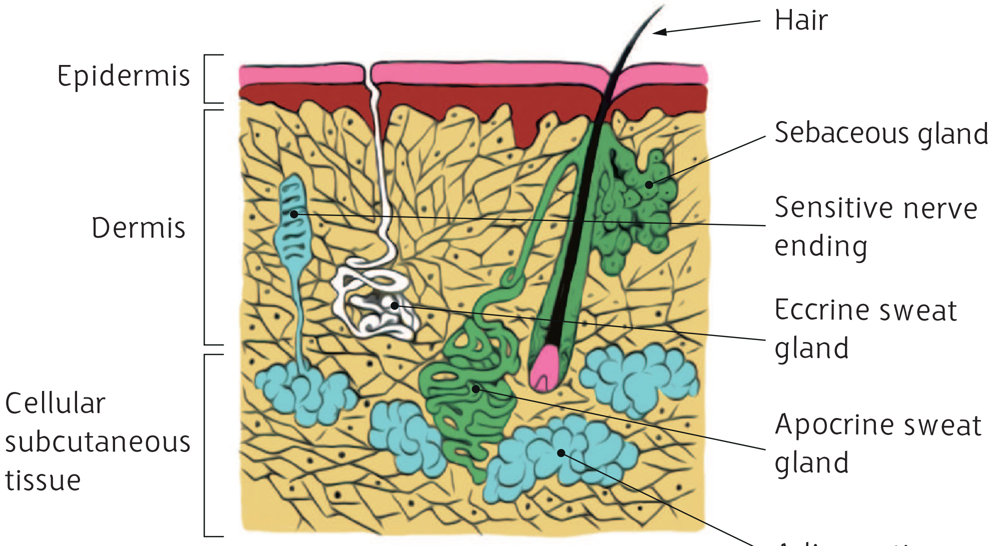

Epidermis
Dermis
Cellular subcutaneous tissue
Hair
Sebaceous gland
Sensitive nerve ending
Eccrine sweat gland
Apocrine sweat gland
Adipose tissue

Figure 24.1. The skin.

- Symptomatic treatment of pain: NSAIDs and topical corticosteroid.

Second degree superficial

- It also affects the dermis.
- Epidermyolysis: bright red-background blisters.
- Painful.
- Preserved sensitivity (sensitivity test: feels and discriminates between pricking and touching).
- They heal on their own.
- Specific treatment for burns.

Second degree deep or third degree

- It affects the entire thickness of the skin.
- The skin is charred or translucent white with coagulated vessels underneath.
- The skin is insensitive but the patient has pain due to concomitant second-degree burns or increased pressure from compression of the tissues underlying the burn.
- Surgical treatment.

The extent of the burn is related to complications and mortality. Mortality in Spain was 0.6 deaths per 100,000 people between 1995 and 1997.

In order to calculate the extent of the burn, it is useful to remember that the palm of the hand represents 1% of the body surface. Another way to calculate the extension is the rule of 9, applicable to adults and children over the age of 10.

- Head: 9%.
- Upper extremity: 9x2, 18%.
- Lower extremity: 18x2, 36%.
- Trunk: 18 x 2, 36%.
- Genitals, palm: 1%.
- Full hand: 2%

Prehospital treatment

Small burns

- Cold water for 10-20 minutes[198], as long as the injury does not exceed 10% of the body surface, as hypothermia can occur in this case.
- Non-aggressive cleaning with mild soap and water or antiseptic.

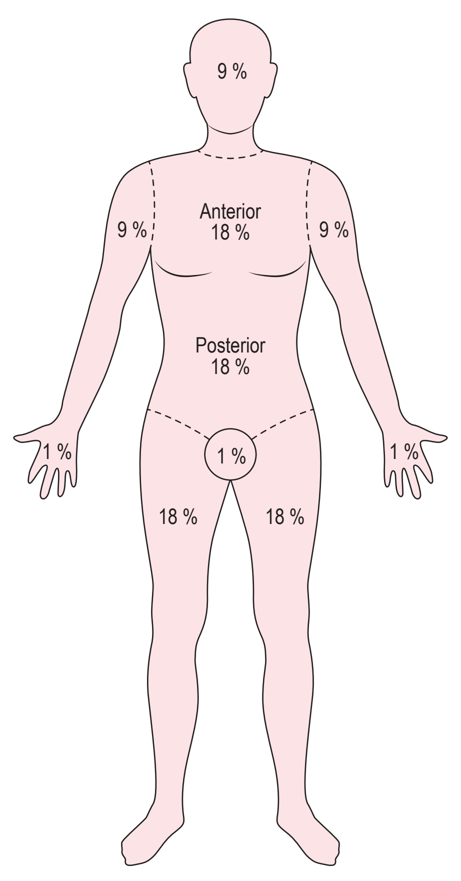


Figure 24.2. Rule of 9.

- Debridement: there is controversy about the need to debride small blisters due to the risk of infection. The protocol of the Vall d'Hebrón Burn Unit (2013) recommends that blisters smaller than 1 cm should not be debrided, especially in sensitive areas such as the fingertips; in this case, they should only be drained and checked after 24 hours. Larger blisters are debrided and a topical cure with argentic sulfadiazine or nitrofurazone is applied every 24 hours.
- First and second surface burns are usually treated with silver sulfadiazine. The deep 2nd degree and 3rd degree, with hydrocolloids **(B)**.[203]
- Tetanus prevention.
- Light bandage.

Large burns

- Initial assessment and CPR, if necessary.
- Control of vital signs.
- Remove compression clothing to avoid the tourniquet effect that worsens the inflammation secondary to the burn. Clothing attached to the burn will be removed in the hospital. Remove chains, bracelets and rings. Trim the hairs at the edge of the lesion.
- Cover the burn with sterile dressings moistened with saline solution.
- If the victim has inhaled smoke, it may be necessary to administer oxygen **(C)** and inhaled salbutamol. If there is a neurological and/or cardiac clinic, assess hydroxycobalamin 75 mg/kg/IV (for cyanide).
- Via peripheral line (14G-16G) avoiding the burned area and the lower extremities. Perfusion of physiological saline to compensate for fluid loss (3-4 mL of serum x% of body surface burned x kg of weight). Half of the calculated amount is given within 8 hours of the burn and the other half within 16 hours.
- Urinary catheterization to ensure that urine output is greater than 0.5 mL/kg/hour (1 mL/kg/hour for electrocution burns).
- Analgesics such as morphic chloride (0.04-0.05 mg/kg/3 h/IV) or fentanyl (1-2 microgr/kg/IV).
- Assess anxiolytics: diazepam 5-10 mg sublingual.
- Assess ranitidine 150 mg/12 h/IV.
- Tetanus vaccination.
- Transfer to a hospital with a burns unit.

SMOKE INHALATION SYNDROME

In fires, injuries from smoke inhalation (toxic gases and particles from combustion) and airway burns are responsible for 80% of deaths.[348]

It is a syndrome produced by the inhalation of asphyxiating gases (CO, CN, CO_2) with oxygen deprivation and elevated temperatures. Thermal damage primarily affects the upper respiratory tract, and can cause oedema of the larynx. Inhalation of particles favours bronchospasm and airway obstruction, increasing the risk of lung atelectasis and pneumonia. Toxic gases, especially carbon monoxide and hydrocyanic acid, increase mortality.

Signs and symptoms

- First hours: the effects of thermal damage and inhalation of toxic gases, burning of nose hair, coughing up dark sputum, sore throat, stridor, choking, tachypnea, tachycardia, bronchospasm, headache, dizziness, stupor, coma and cardiorespiratory arrest are observed.
- First five days: may have non-cardiogenic lung oedema due to the delayed effect of irritant gases. Risk of pneumonia.
- First days and weeks: resultant cerebral hypoxia, pulmonary atelectasis, subglottic stenosis and pneumonia are observed.

Treatment

- Remove the victim from the fire scene.
- Initial assessment using the A-B-C-D-E method and cardiopulmonary resuscitation, if necessary. Then administer 100% humidified oxygen and adjust to achieve SpO2 94-98%. Assess early intubation because it may be difficult later due to oropharyngeal oedema and/or airway burns.
- Transfer to hospital.

CARBON MONOXIDE POISONING (CO)

Cases of carbon monoxide poisoning have been reported in tents and snow caves. Risk factors include:

- Cooking inside the tent: avoid having the stove on for a long time. Keep the pressure on the stove high, use the purest possible fuels, use small diameter pans, check that the flame is completely blue and avoid low heat.
- Yellow flame: turn off the stove, pressurise it, ventilate the tent for a few minutes and turn it on again.
- Inadequate ventilation of the tent: the ventilation opening must be at least 50 cm2. Snow caves have worse ventilation than tents. If snow covers the tent, you can eliminate ventilation.

- If a headache and tachycardia appear, suspect intoxication.
- Dehydration, hyperventilation and altitude contribute to worsening the effects of the toxicity.

DROWNING

A person in contact with water may aspirate it or develop a spasm of the larynx in order to prevent aspiration.

The first case is wet drowning, which corresponds to acute pulmonary oedema.

The second case is dry drowning (10-15% of those drowned), which corresponds to a syncope with respiratory arrest.

In both cases, there is hypoxia, which can be fatal.

Sudden immersion in very cold water may result in shock due to the temperature difference.

Hypothermia plays an important role in death by drowning because it causes cardiac arrest secondary to an abrupt post-immersion vagal reaction, or by respiratory depression, followed by ventricular fibrillation and cardiac arrest, in the case of prolonged immersion in cold water. In water at temperatures of 20 °C or below, you are more likely to survive by staying still than by swimming. However, if the shore is close by, it is interesting to know that moving your arms in cold water involves more heat loss by convection and conduction than moving your legs, since your arms have less insulating fat, so it is recommended to intensify your leg movements and to minimise those of your arms.

Age, type of water (fresh/salty) and temperature do not predict the prognosis. The only factors of prognostic importance are the duration of the immersion (greater than 10 minutes) and the duration and severity of the hypoxia.[198]

The longest example of anyone recovering from immersion without after-effects was that of a two-and-a-half year-old boy who had fallen into water at 5 ºC, remained submerged for 66 minutes and, after cardiopulmonary resuscitation, was treated for hypothermia with extracorporeal circulation. As a result, CPR is recommended for all drowned persons unless there are signs of putrefaction, lividity, or *rigor mortis*.

Signs and prognosis

- Immersion for more than 10 minutes.
- Cardiopulmonary resuscitation for more than 25 minutes after recovery from hypothermia.
- Arrival at the hospital in cardiorespiratory arrest.
- Findings of fibrillation or ventricular tachycardia on the electrocardiogram.
- Pupils are nonreactive.
- Glasgow <5.
- Persistence of the coma for more than 24 hours.
- Severe acidity (pH <7.1).
- Respiratory arrest.

Consciousness and reactivity have been correlated with survival. Deaths were observed only in those accident victims who were in a coma, and who were still in a coma on arrival at the hospital; however, no deaths were observed in accident victims who were found to be reactive at the scene of the accident, even if they were in a lethargic state, and who continued to be reactive on arrival at the hospital.

Treatment[349]

- Cardiopulmonary resuscitation (CPR). Starting ventilation as early as possible is associated with longer survival. During CPR, 50-86% of the injured suffer from vomiting. In this case, turn the victim's head, considering the head, neck and torso as a unit if cervical injury is suspected.
- Around 0.5% of these accident victims have cervical injury.
- Do not remove aspirated water from the airway. Abdominal compressions may cause gastric fluid regurgitation.
- Prevent and/or treat hypothermia.

25 INJURIES IN CANYONING AND CAVING

Canyoning and speleology are sports in close contact with the mountain and its elements, especially water. Water is the main determinant in the formation of canyons and caves, due to its chemical or physical reaction with the rock. Canyons, caves and chasms can take many forms, with some common characteristics, such as cauldrons, waterfalls, whirlpools and siphons, and others specific, such as cracks, drains, wells and springs.

Canyoning and speleology are physically and mentally demanding sports with water hazards, extreme temperatures, exposure to high altitude, confined spaces and dangerous surfaces. Poor knowledge of the environment, progression skills and specific equipment, can lead to injuries, with a prolonged rescue time due to the circumstances of the environment.

EPIDEMIOLOGY

Canyoning

Ideally, canyoning follows a watercourse with a reasonable amount of water and slippery soil. Generally, there are no exit alternatives and the course must be followed to the end of the ravine. It combines various technical progression skills such as hiking, climbing, jumping, rappelling and swimming. The necessary equipment includes climbing gear, static ropes, helmet, wetsuit, special shoes, whistle, knife and waterproof bags.

The difficulty of the canyon is given by the vertical sections and the amount of water. For this reason, canyon climbers must know the topography of the canyon, the drainage area and the weather forecast in order to calculate the length of the ropes and to avoid flooding.

Rope progression techniques are based on releasable rappels to avoid drowning if you get caught in the rope under a waterfall. The ropes must be installed in such a way as to avoid friction that could damage them and they must end up out of the water without a final knot, to avoid being trapped in the rope remaining in the pool, with the consequent risk of drowning. Boiling kettles and whirlpools cause a depression that produces a relative vacuum, entailing a risk of entrapment and drowning. Escape from a strong current may require for the canyonist to remain submerged, resisting the temptation to immediately emerge to the surface. Fallen rocks, branches and trees also carry a significant risk of entrapment and drowning.

Most injuries are traumatic (75-92%), and affect mainly the extremities, especially the ankles due to jumps and slippery terrain. Dislocations and complete shoulder and wrist fractures account for 9% of upper extremity injuries. Accidents due to wrong manoeuvres can lead to severe multiple trauma and underdiagnosed spinal cord injuries.[87, 350]

Drowning, due to errors in water flow assessment or wrong rope manoeuvres, represents the second leading cause of injuries and one third of deaths in European canyons87, being rare in Australia and the United States.[351] As the water level rises, the speed and power increase exponentially; as the velocity of the current doubles, the force of the water against an object quadruples.

Immersion in cold water precipitates drowning, and hypothermia can occur in less than half an hour, even with a wetsuit. Despite the fact that 1 in 5 canyonists report having experienced hypothermia,[351] this has only been reported in 8% of the rescues.[350, 352]

Heat stress and dehydration can occur in hot regions. Cases of acute ischemic heart disease, stroke, hypoglycaemia, infections, animal bites, cactus lesions, etc. have also been reported.[87, 351, 353, 354] Deaths account for between 3 and 5% of rescue operations.[87]

Caving

The exploration of speleological routes ranges from progression through chambers so large that it is difficult to distinguish distant walls, to almost impenetrable cracks; and from almost horizontal caves to vertical chasms. Lack of light and slippery terrain are often constant. Unlike canyons, caves tend to develop into endless underground labyrinths, with no exit at the end.

Speleology requires the use of ropes to provide safety in the event of a fall. The material also differs from that used in canyon descent, with abseiling devices with assisted braking, hand and chest ascenders used to climb the ropes, light sources and protective suits with an outer layer of Cordura® exterior. Underwear should remain warm even when damp, providing comfort in the underground environment.[355]

The atmosphere may contain dangerous levels of carbon dioxide, methane, hydrogen sulphide, or radon. Underground fauna can transmit unusual pathogens, such as *Histoplasma capsulatum, Leptospira* and *Borrelia* species, recurrent tick-borne fever, and rabies virus.

Landslides and rock falls can occur.

Traumatic injuries are the most frequent, affecting mainly the extremities (50%) and head (15%). Spinal injuries are under-diagnosed. The most common cause is human error, followed by loss of cave integrity. Continued exertion, multiple rock impacts, and compression caused by the harness can also cause muscle damage and rhabdomyolysis.[356, 357]

Accidental hypothermia is the most common pathology in speleology. Only 5% of rescues have been observed for medical conditions such as heart disease, seizures or gas poisoning.

Infections are extremely rare.[356]

Deaths account for about 6% of rescue operations Most common causes are trauma and drowning.[356] Despite its low frequency, suspension syndrome (or harness hang syndrome) due to the specific progression manoeuvres of speleology is an injury that can lead to death.[272, 358]

CANYON AND CAVE RESCUES

The number of accidents has been on the rise since the second half of the 1980s.[350] Rescue in canyons and caves is characterised by specific material, but above all by the long rescue time which requires stabilizing the victim at the scene of the accident.

Rescue time, risk assessment and communication

Rescue instigation time is delayed due to difficulties in radio or telephone communication, difficulty in the departure of team members to request assistance, and difficulty of the rescue team in accessing the victim. Rescue time in canyoning varies between 90 and 210 minutes, up to 12 h.[350] In speleology it is even greater and can last 5 days or more.[355, 356]

The evacuation of the victim must deal with technical aspects such as reduced spaces or the verticalisation of the victim with possible hemodynamic deterioration. The person in charge of the team must evaluate the topography of the site, the need to modify the cave (digging, bursting galleries, etc.), the risk of increased water levels, gas poisoning or hypothermia, in order to advise the rescue operation according to the injuries of the victim.[359]

Wired and waterproof communication equipment is required.

Medical equipment

Medical equipment must be individually packed in plastic bags and kept dry in special buoyant containers or bags. Weight and volume must be limited. Electronic devices should be avoided, although the pulse oximeter and an epitympanic thermometer may be helpful. A bag of health care material should be carried according to the A-B-C criteria; other bags of nutrition material, personal hygiene, including urine output/evacuation control, and hypothermia prevention; and yet another bag with immobilisation devices (KED, neoprene equipment, etc.). The possibility of being able to use oxygen is low due to transportation hazards. The use of alternative routes for perfusion and drug administration (intraosseous route) is valuable because of the long rescue time. It should be noted that hypothermia may alter the pharmacokinetics and pharmacodynamics of medicines.

One of the key elements is to place the material in a warm place and/or in a medical tent.

Patient assessment, primary care, and evacuation

Care must be tailored to the environment, the limited medical equipment and the long rescue time.

Risks should be assessed, safety checked and care initiated using the A-B-C-D-E system.

The victim should be moved to a safe place, isolated from moisture to avoid hypothermia. Re-evaluation should be ongoing to recognise possible complications.

Prior to evacuation, the victim should be correctly placed on the stretcher with the understanding that evacuation can be very prolonged. Drugs and fluids must be administered in bolus form prior to evacuation, due to difficulties in maintaining an IV perfusion line.

Drugs and measures for the prevention of complications and treatment during prolonged bowel movements (e.g. antibiotics for the risk of contamination of the wound by water; protection for the prevention of pressure injuries) should be considered. Dislocations and complete fractures should be reduced and immobilised as a priority for the analgesic effect and to facilitate rapid evacuation.

For canyon rescues, special lightweight stretchers are used, equipped with a dry bag allowing them to pass under a waterfall, head protection and two-piece protection for easy transport. For cave rescue, lightweight stretchers of compact design are used, adapted to confined spaces. Victims are fixed with a full-body harness. The stretchers can be adapted to all rope rescue techniques and allow the victim to be transported horizontally, vertically or at an angle to adapt to the terrain.

It should be noted that health workers often cannot be near the victim (zip lines, counterweights).

26 AVALANCHES

An avalanche is the displacement of an upper layer of snow above another, lower, layer of snow.

Avalanches are the leading cause of serious accidents in mountain skiing.

TYPES OF AVALANCHES

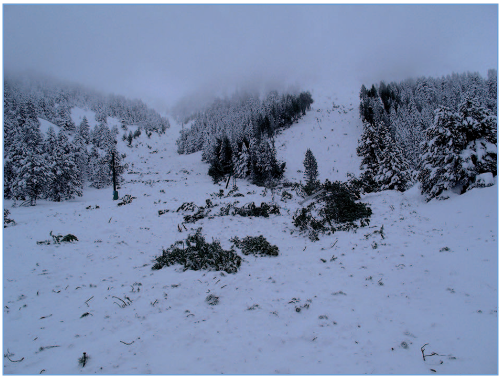


Figure 26.1. Avalanche.

Recent snow avalanche

Recent snow avalanches usually originate during snowfall and in its immediate aftermath. They occur when recent snowflakes lose their initial cohesion: the dendrites break and become visible needles when snow falls from tree branches. For such an avalanche to occur, heavy snowfall (30 cm in 24 h) is required.

Depending on the temperature at the time of precipitation, two types of avalanches can occur: recent wet or recent dry snow avalanches.

Recent dry snow avalanche

Occur when the temperature is below –5 ºC. It is a very thin snow and, when it reaches a high speed (up to 400 km/h), it behaves like an aerosol: a large cloud of dust. In this case, the avalanche does not respect the relief and descends directly to the bottom of the valley. If the speed is slow, it is nothing more than a dry snow wash.

The shock wave that precedes the snow mass can throw a victim about with great violence; the snow quickly infiltrates the airways, obstructs them and fills the lungs, causing a victim to suffocate.

New wet snow avalanche

Occur when the temperature, at the time of precipitation, is close to 0 ºC. No powder snow avalanches form, they behave similarly to melting avalanches, forming viscous casts that slide at slow speeds.

Avalanche caused by melting

Occur when there is liquid water in the snowy mantle, either due to high temperatures, rain, fog or warm wind. They are typical in spring, but can also occur in winter with higher temperatures. The most affected slopes are usually those facing south, as they receive more sunshine. They are composed of a high-density snow mass (200-600 kg/m^3), with relatively slow speeds (10 to 20 km/h), so they are more dangerous due to their mass than their speed. They tend to descend through corridors and torrents, eroding the snowy mantle, and if they affect the soil, they drag everything in their path (stones, trees, mud, etc.).

Slab avalanche

The slabs are usually located on open slopes, especially in convex areas. Slab avalanches are characterised by the formation of a scar in the exit area of the plate, which can range from 5 cm to 2 m or more. Generally, the slabs are formed by the accumulation of snow due to the effect of the wind. They can reach speeds of 20 to 50 km/h. They are the ones that cause the most accidents, as they are often hidden under subsequent snowfalls and the weight of the skier can trigger the avalanche.

There are two types of slab avalanches, hard slabs and cold slabs.

Hard slabs

Hard slabs can be suspected by the presence of cornices. They are rigid and fragile plates (more fragile the lower the temperature), formed by the accumulation of snow carried by the wind and accumulated on the leeward side. They are lenticular in shape and have few anchorages. Their matt colour differentiates them from the surrounding snow, but they can be invisible, when they are covered by subsequent snowfalls.

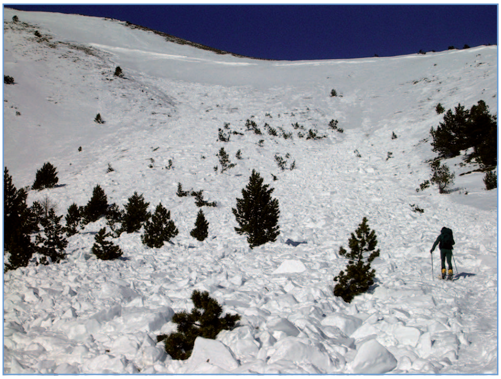


Figure 26.2. Slab avalanche.

Cold slabs

The cold slabs is made up of snow generally carried by a weak wind, and in the event of an avalanche, it disintegrates quickly.

FACTORS THAT FAVOUR TRIGGERING OF AVALANCHES

Intrinsic factors

These are the non-variable factors specific to the slopes:

- Gradient: in our latitudes, most avalanches occur on gradients of between 30º and 45º. Gradients higher than 50º are purged during snowfall and those lower than 25º are insufficient for snow to slide.
- Convex zones: in concave zones the forces acting on the snow cover converge, so it tends to be more stable than in convex zones where the forces are divergent and can therefore produce a break in the snow cover.
- Soil roughness: the rougher the soil, the more anchor points it will provide to the snow cover (forest, rocks, etc.). If it is not very rough (long grass, polished rocks, etc.), avalanches will start more easily. Soil roughness is only effective as long as it has not been covered by initial snowfall.
- Vegetation: closely related to the previous point, if there is dense forest, it offers more anchorages than a thin or non-existent forest. In forests with steep slopes, be careful when crossing avalanches that have caused logging, as new avalanches may occur during heavy snowfall. In a forest of conifers (pines, firs, etc.) in which stripes of deciduous trees are observed, it must be suspected that avalanches may fall along such stripes.
- Orientation of the slopes towards the sun: on the south-facing slopes the sunshine is more direct and lasts longer. In general, transformations will be faster, especially in spring when the fusion processes make these aspects more dangerous. On the northern slopes, the cold makes the transformations slower and, therefore, the shady areas will be have greater instability in winter.
- Orientation of the slopes with respect to the prevailing winds: the formation of cornices and slabs is directly related to the wind direction. In the Pyrenees, the prevailing winds after the passage of Atlantic fronts are usually from the north and northwest, so the slabs will be located on the slopes facing south and southeast.

Extrinsic factors

These are factors that vary over time and do not depend on the characteristics of the slope.

- Meteorological factors
  - Situations linked to heavy snowfall: rainfall increases snow cover weight, which absorbs more of the load over a long time period than over a short one, so that intense rainfall will cause rapid destabilisation. As a general rule, a precipitation of more than 30 cm in less than 24 hours predicts high avalanche risk. If temperatures remain low, snow cover stabilisation will be slow and the danger of powder snow avalanches will be maintained for a long period of time. If temperatures are above 0 °C, avalanches of wet snow will rapidly fall and, after a few days, stability will be significant.
  - Cold anticyclonic situations: in the Pyrenees, autumn snowfalls usually occur, leaving a blanket of 40 to 50 cm. It is often the case that long cold stages occur afterwards with very little snowfall. The combination of a cold thin snow blanket –i.e. one having a high thermal gradient– facilitates the formation of layers of low cohesion. Lasting cyclonic situations propitiate the formation of ice on the surface. In the case of snowfalls, they will become the perfect layers to facilitate avalanches.
- Overloads: additional weight added over the snow cover (people, animals, falling rocks, etc.).

RISK ASSESSMENT. THE EUROPEAN AVALANCHE DANGER SCALE

- Risk 1 (weak): avalanches are possible on some steep slopes, generally due to heavy overloading. Small falls can be triggered naturally. Despite the weak and localised risk, security measures should not be overlooked.
- Risk 2 (limited): avalanches may occur after a severe overload (group of skiers) on orientation and altitude slopes as indicated in the avalanche warning bulletin. No spontaneous falls of large avalanches are expected. Excursions should be planned in such a way as to avoid the orientation and altitude slopes indicated in the bulletin.
- Risk 3 (considerable): avalanches can occur, even due to a low overload (one skier only) and on numerous slopes. Medium to large avalanches can occur spontaneously.
- Risk 4 (strong): strong instability on most slopes, the characteristics of which are described in the bulletin. Avalanches can be triggered by a slight overload (a single skier). Excursions should be limited to areas of moderate slope, the lower part of the slopes may be exposed.
- Risk 5 (very strong): very strong instability of the snow cover due to heavy snowfall, generally with wind, which has led to a very rapid increase in the snow cover thickness, or even to excessive heating accompanied by rain, which has resulted in a transformed snow cover. Large and numerous avalanches can occur even in low slope areas. Excursions must be cancelled.

Another indicator of risk is the amount of snowfall in the last 24 hours:

- From 20 to 30 cm: avalanches on steep slopes.
- From 30 to 60 cm: avalanches on medium slopes.
- From 60 to 90 cm: generalised risk.

SAFETY DEVICES

The basic safety elements for the immediate relief of avalanche victims are the trilogy (AVD, probe and shovel). It should be practised at least 2 or 3 times per season.

- AVD (avalanche victim detector): are small emitter-receiver devices weighing about 300 g, powered by 1.5-volt commercial batteries that, once activated, emit a radio signal that usually reaches between 30 and 80 meters. When a person is buried by an avalanche, the victim's colleagues place their AVDs in the receiving position and look for the injured person. The AVDs make it possible to find a victim very quickly.

- The shovel: without a shovel it is practically impossible to dig the victims out. A metal shovel with a long handle should be chosen. In order to free the head of the victim as soon as possible, shovelling should be started about 50 cm in front of the point where the victim has been located.
- Probe: it must be metallic with a steel cable and have a minimum length of 240 cm, divided into folding sections of 40cm. It is the most efficient system for locating the buried victim once they have been detected with by AVD.
- Mobile phone: if there is coverage, it can be useful to avoid wasting time asking for help. It should be remembered that it must be switched off during the victim search operation, as it may interfere with the AVD.
- The Avalung is a contained filter system that allows air to be extracted directly from the snowpack. A valve redirects the expired air containing CO_2 away from the filter and the oxygenated air catchment area. The system must be worn on the outside of any clothing.[360, 361]
- The Airbag: this is a balloon incorporated in the backpack that swells when the avalanche falls. It has reduced mortality from 48% to 15% in powder snow avalanches by preventing victims from being buried **(B)**.

SAFETY TESTS

To know the slope

- The two ski-sticks are placed in a 90º position, supporting the horizontal pole on the slope. If the horizontal baton matches the handle of the vertical baton, the slope is 45°. If it coincides with the half of the vertical cane, the slope is 30°.

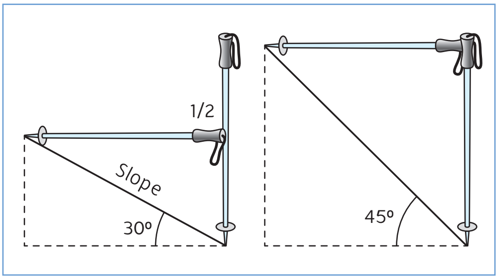


Figure 26.3. Slope test.

To know the stability of the snow blanket

- Rutschblock test: the snow mantle does not have a good cohesion if, during loading, the cut block becomes detached.
- Ski-stick test: this consists of spiking the stick into the snow to check the cohesion of the surface layers. If the top layer is of low cohesion, the stick is easily pushed into the snow. If there is a plate, it can be checked for a layer of low cohesion underneath it, as there is less resistance. The most stable situation is when the snow offers greater resistance the further the stick is pushed into the snow. It is a very quick test that can be done during an excursion. Only the most superficial layers can be recognised.
- Shovel test: it consists of isolating a snow column, attached to the rest of the mantle by its upper part, where the shovel is spiked into the snow by pushing it towards the skier, thus locating the layers where mantle slipping occurs.
- Compression test consists of isolating a block of snow that is as wide and elongated as the body of the shovel blade, and applying pressure to it in 3 different phases. The first phase gives 10 very soft blows of the hand on the block, only leaving the weight of the hand on it. If it doesn't break off, do 10 more forearm blows again. In the event that nothing happens, give 10 more blows, this time with the arm well extended.

To make a more or less reliable calculation of the state of the snow mantle, you can say that if it is triggered in the first 15 strokes, you have to be more cautious and more attentive when skiing.

PREVENTION

Before the activity

- Read the weather forecasts and the avalanche warning bulletin.
- Ask the opinion of local professionals in the area (high mountain guides, ski patrol members).

- Ask yourself the following questions: is there a strong accumulation of snow?; has the wind blown during and after the last snowfall?; has there been a strong increase in temperature?
- Always go out with company and with good information on the planned itinerary.
- Each member of the group should bring an AVD and a shovel, and a mobile phone if they consider it convenient.

Table 24.1. Nivotest (Robert Bolognesi)

Risk Factors	Score
Rain during the last two days?	3
Snowfall >20 cm during the last 3 days	3
Wind in the last five days?	3
Air temperature >0 °C?	1
Reduced visibility?	3
Deep snow (on foot, do you sink between 20-40 cm)?	3
Very deep snow (on foot, do you sink more than 40 cm)?	5
Wet snow?	2
Irregular snowfall (thickness or structure)?	1
Snow accumulated by the wind, or cornices?	5
Fragile inner layer (possible after hailstorms, with a layer of frost or on sunny slopes after a period of clear, cold weather)?	
Has there been an avalanche during the day?	4
Was there an avalanche a day or two days before?	2
Are there fractures in the snow mantle?	1
Itinerary without protected areas?	4
Exposed itinerary (projections, cracks, seracs)?	1
Little frequented itinerary?	1
Route with steep slopes >30º?	4
Steep, convex slopes?	1
Low-tech level skier?	1
Skier in bad physical shape?	1
Skier with no shovel, probe or AVD?	1
Group of >5 or <3 people?	1
Group with no rescue experience?	1

If the total is more than 7 points, the risk is real, if the total is more than 21 points, it is better to give up the excursion. Ignore alarmist indications if all slopes are below 25 degrees or are in a closed forest.

If the risk is high, it is preferable to give up the trip, except perhaps for known routes where it is physically impossible for an avalanche to occur.

During the activity

If during the course of the excursion there is no choice but to pass through an exposed area, the following recommendations should be followed:

- In case of doubt, do not hesitate to give up and turn back. It is very important not to listen to the promptings and provocations of others.
- Release the straps on your poles and skis and carry your backpack hanging from one shoulder strap.
- Cover your airways with a tissue.
- Cross over the highest area one by one, preferably choosing the ridgelines and avoiding places where snow accumulates. Be wary of slope changes.
- A cornice suggests the presence of wind slabs. Detachment of the ledge can cause an avalanche.
- The heaviest one should cross first. Never go down one after the other, as the slope will be heavily overloaded.
- Avoid flanking and conversions, but in case you have to flank, keep good separation between group members.
- Watch the skier crossing the exposed area. If they are caught in an avalanche, try to follow them with your eyes and identify where they disappears, as the search will begin at that point.
- Enter the slope gently, look upward paying attention to the least noise and always be prepared to ski away. Do not stop until you have left the exposed area.
- Be wary of existing ski tracks. An avalanche can be triggered after several skiers pass by.
- Mark a lateral escape route in case of an avalanche, and a safety zone on the slope

or under the slope to wait for the rest of the group. When the first skier has reached the safety zone, the second skier can go down to meet them. Do not descend the entire slope all at once, go from safety zone to safety zone. All members of the group will observe the same rules of surveillance, as an avalanche can occur at any time.

- Make sure there are no other skiers on the slope; if there are, wait for them to move away. If another group of skiers arrives, stress that they wait until the first group is off the exposed slope before going down.
- Although it is easier to cause an avalanche when going down, it is more difficult to avoid it when going up, so it is important to assess whether it is better to remove seal skins and descend diagonally, losing as little height as possible while maintaining a good speed, and, once the exposed area is crossed, continue skinning.

Behaviour in case of being surprised by an avalanche

- Ski diagonally to the nearest side and protect yourself behind a large rock or on a rise.
- If the front face is so wide that it will not be possible to reach a side, consider skiing in direct descent without stopping, this is possible if the slope is short and ends in a plain, as the speed of the avalanche will reduce on the plain.
- If you can't ski away, try to get rid of anything that gets in the way and try to stay on the surface and, if possible, to the side or hold onto rocks or trees. The higher up and closer to the side the skier is, the shallower the depth at which they will be buried.
- If it is not possible to remain on the surface, grasp the opposite arm in front of the face with one hand in order to facilitate the creation of an air chamber around the face. When the avalanche has stopped, hit the snow to make an air chamber around the face.
- Yell only sporadically, with short, high-pitched sounds to get them through the snow cover, and wait calmly for help.

Assisting a skier trapped by an avalanche

- The trapped skier's companions should act quickly but calmly, try tracking the person with their eyes and identify the place where the skier disappears, as the search will begin at that point.
- Then, look and listen, as shouts may be heard, there may be a part of the individual that is not buried or pieces of clothing that help find the victim.
- Pay particular attention to obstacles encountered on the trail followed by the avalanche, by intensifying the search for these obstacles.
- Place observers or lookouts to sound the alarm in the event of a new avalanche and provide escape routes to a safe area.
- If you have a mobile phone, inform the emergency services indicating the nature of the accident, exact location or access route in case of doubt. Turn it off during the search operation to avoid interference with AVDs.
- Determine and split the tracking area and start the AVD search; if it is a large avalanche, use horizontal sweeps, and if it is small, use a downline search.
- When the first signal is detected, choose the search method (cross, directional, mixed) and follow the search for accuracy until you locate the injured person.
- Once found, first dig the head out to start providing first aid.

RESCUE

Almost 90% of those buried appear less than two metres from the surface.

Search procedures with AVD

Cross method

The best known method; it is systematic and effective.

- Once the first signal is received, the receiving point is marked and 180° horizontal searches are performed to orient the device to the position where the signals are heard loudest.

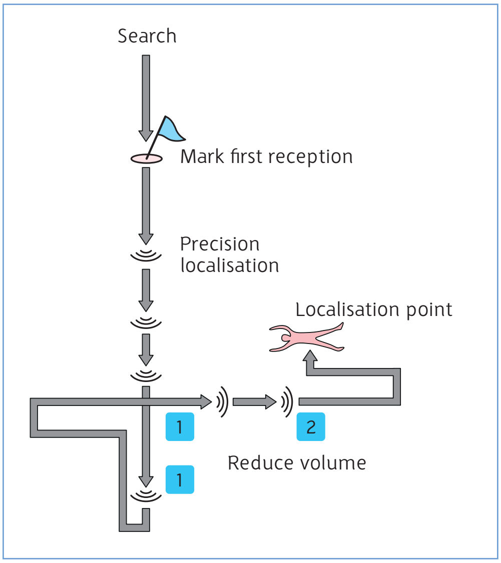


Figure 26.4. Search with ADV.

- From the point of first reception, move straight down to the point of maximum intensity and mark it. Continue in the same direction and check that the volume of the signal decreases; if so, return to the previously marked point.
- From this point, continue in a perpendicular direction to the line previously followed, from right to left. If the signal decreases, the direction is wrong, so return to the previous point and continue in the opposite direction, checking that the signal intensifies. When this occurs, the volume of the device must be decreased to fine-tune the sounding.
- In this direction another point of maximum intensity is determined, and another perpendicular direction is taken, as has been done previously, seeking an increase in sound.
- If an increase occurs, the process is repeated, decreasing the volume and signalling in each new direction the point of maximum intensity. If it is difficult to establish where the sound is loudest, the two weakest points should be indicated and the middle point should be pointed out.
- The same procedure is continued until the volume has been reduced to a minimum. In this situation, the movements to be made with the device are already very short. Do not rush to the victim, be systematic to the end in order to better pinpoint the position and gain time.

Directional method

This method of locating can reduce the search time if you have enough practice, as it prevents erroneous attempts. The aim is to approach the victim by tuning the emission waves of the device, which propagate in two beams of concentric circles opposite each other.

- After the first reception, the device is rotated until the angular position to determine where the sound is most intense; this determines that the receiving device is on a tangent to the wave lines of the transmitting device.
- Follow the direction of the arrow on the AVD for about 5 meters, or the opposite direction, as in principle either direction can be good.
- If the signal increases, it is the correct direction, if not, change direction.
- The AVD is re-oriented every 5 meters. At first, always checking for the direction in which the volume is at a maximum. When in doubt, choose the direction that is the least distant from the one followed. Lower the volume when the signal intensifies as with the previous method.
- The procedure of searching for the angular point of the loudest sound is repeated more frequently the closer you are (every 3 meters).
- Continue until the volume is at its minimum, and then track the surface as in the previous case.

Mixed directional methods

With plenty of practice, the directional method can be optimised to reduce search time:

- When the first signal is received, the AVD is oriented, as in all methods, find the position where the signal is most intense.
- The AVD must then be moved perpendicularly to both sides of this initial position of

maximum reception. Note that the modifications can be of three types depending on the position of the transmitter and receiver antennas, and the search path varies for each type:

- When moving, the signal decreases on both sides: this is the exceptional case where the antennas are facing each other, the victim is in a straight line. Move forward to confirm this, as it may be in the opposite direction.
- The signal increases to one side and decreases to the opposite side: the antennas are parallel, the direction to follow will be the one in which the signal increases, this is the case in which more time is saved, since it avoids turning around as would be the case with the directional method.
- Nowhere is there a significant variation in volume: the antennas are in any other position, so the directional method is followed.

Rescue dogs

A dog's sense of smell is two hundred times more developed than a man's and can detect a victim at a depth of two and a half metres. In ten minutes you can explore an area of 5,025 meters. A team of twenty people takes an hour to do the same job using the quick sounding scan. The dog should not be distracted while doing his job. Do not eat, smoke, or urinate in the avalanche area. Do not sit in the area of operation.

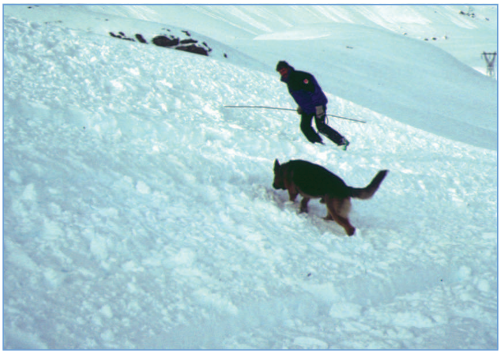


Figure 26.5. Rescue with a dog.

Rescue by probe poles

It is such a slow method that many times it only serves to remove the lifeless bodies of the victims. It is practically reserved for rescue groups.

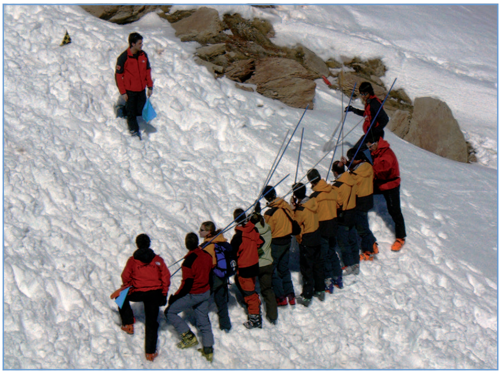


Figure 26.6. Probe search.

Quick probing

Rescuers are placed half a metre apart, separating the feet 25 cm and placing the probe 70 cm in front of them. First they probe in the middle, in front of the left foot and in front of the right foot, and then they advance about 70 cm. With this method, a group of 12 people takes 4 hours to probe a hectare and has a 76% chance of finding the victims.

Thorough probing

The rescuers are placed at 25 cm from each other, separating the feet 50 cm and placing the probe at 25 cm in front of them. First they probe in the middle, in front of the left foot and in front of the right foot, and then they advance about 25 cm. A group of 12 people takes 20 hours to probe a hectare and has a 99% chance of finding the victims.

IMMEDIATE TREATMENT OF THE VICTIM[362, 363]

Every buried person is a polytraumatised hypothermic until proven otherwise. The probability of survival is 91% at 18 minutes of burial, 34% at 35 minutes (very severe asphyxiation in victims without cavity or airbag) and between 35 and 90 minutes a flat phase is entered (latent phase in airbag victims), followed by a 7% drop in survival at 130 minutes (death of victims from asphyxiation at airbag depletion or slow onset of hypothermia). For every hour that you are buried, your temperature drops by 3 °C.

The immediate rescue of the victims is a priority, but the safety of the area must be taken into account since the fact that an avalanche has fallen does not prevent another avalanche from falling in the same place. The first search option will be with AVDs (avalanche victim detector) by the colleagues themselves. The next step will be the dog search and finally, probing. Once the victim has been found, the AVD should be turned off to avoid confusion if there are more victims.

Buried victims who do not have a respiratory cavity in front of their mouth and/or nose die from asphyxiation in less than 35 minutes. It is therefore very important to recover the victims within 35 minutes and access the face to unblock the airways before proceeding to dig them out completely. When digging the victim out, do not pull them, but dig a large hole around them, clearing the head first to start first aid.

If the duration of burial is longer than 60 minutes, hypothermia below 30 °C is possible; a person buried under an avalanche cools down by 3 °C every hour (0.6-9 °C per hour). The measurement of the epitympanic temperature is not an option because the external auditory canal will be wet and filled with snow. The only measurement that will be appropriate is the lower third of the oesophagus.

If the duration of the burial is less than 60 minutes and/or the core temperature is greater than or equal to 30 °C, the victim is suffering from asphyxia, in the absence of lethal injuries, and is resuscitated in exactly the same way as an unburied victim, i.e. if the person has not recovered within 20 minutes.

If the duration is longer than 60 minutes and/or the temperature is below 30 °C, it is very important to assess the respiratory cavity. If the respiratory cavity is not obstructed, this is a patient with grade IV hypothermia, so resuscitation will not be suspended until rewarming by active internal reheating unless the serum potassium is greater than 8 mmol/L.

In the previous situation, but with the respiratory cavities (mouth and nose) obstructed by hard snow or frost under pressure, resuscitation manoeuvres are not initiated, since death by asphyxiation has occurred. If the existence of an airway in the cavity is uncertain, resuscitation manoeuvres are initiated.

A person who has been buried under snow, breathing only from the air chamber surrounding his or her airway, may have hypercapnia. When released from the avalanche and breathing ambient air, the hypercapnia disappears and the respiratory centre loses the respiratory stimulus of CO_2 and may experience a respiratory arrest. Therefore, in addition to protecting against hypothermia and hypoxia, hypercapnia (the 3 Hs) must be taken into account.

Subsequently, we act as with any other injured person, taking into account the specific characteristics of those injured by avalanches. The accident victims who have been completely buried (head and trunk in the snow) must be admitted to hospital for 24 hours for observation due to the risk of pulmonary complications (aspiration, oedema, etc.) (Figs. 26.7 and 26.8a, b).

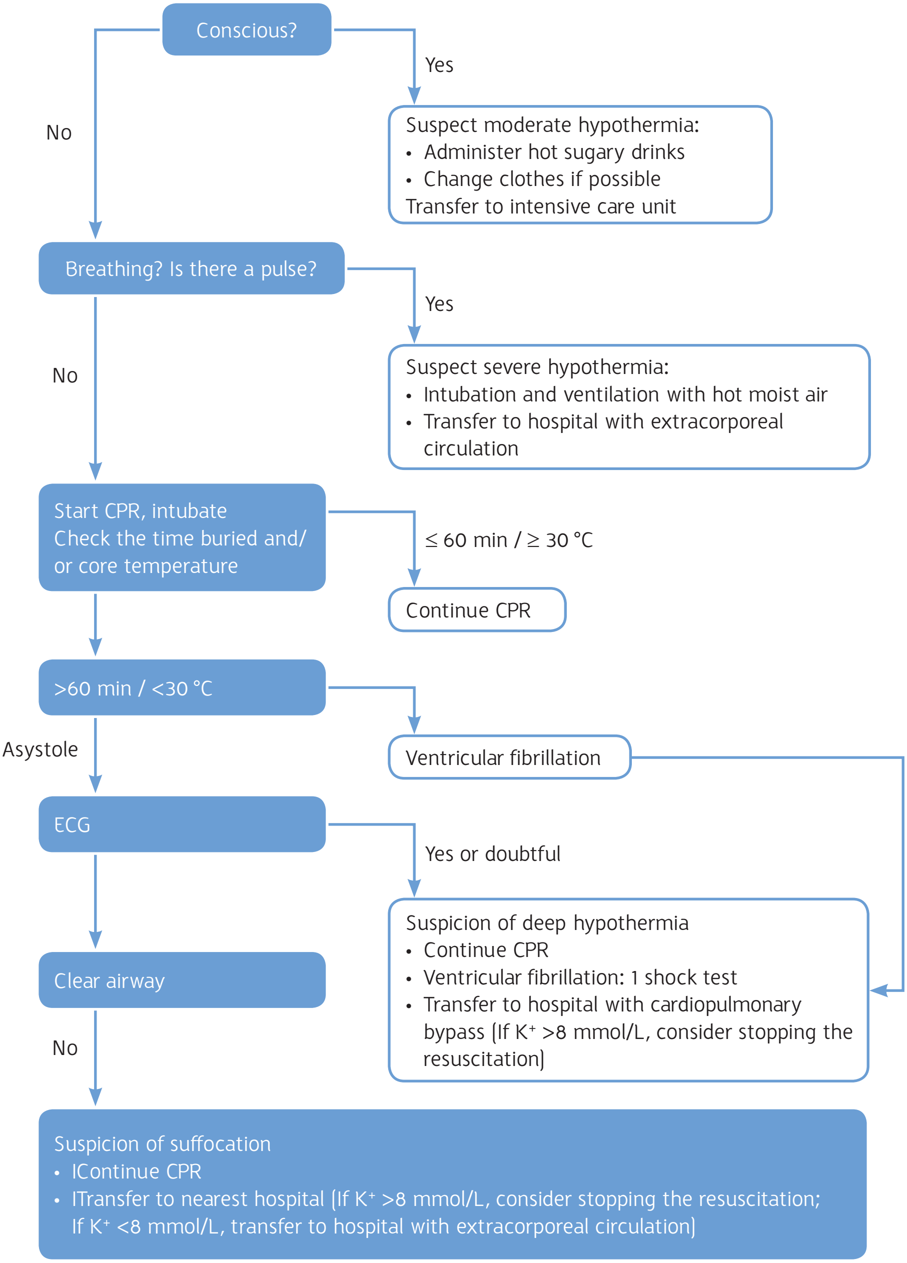
PROGNOSIS OF PERSONS INJURED IN AN AVALANCHE[364, 365]

Among those rescued in the first 15 minutes, survival was 93%. After 35 minutes, the only victims with cardiac arrest who survived were those with an air chamber in front of their mouth or nose.

According to the Institut Cartogràfic i Geològic de Catalunya, in the 25 seasons from 1989 to 2014, 178 avalanches have been recorded, with a total of 36 fatalities and 76 injured, representing an annual average of 1.44 dead and 3.04 wounded (18%).

In the Pyrenees, trauma is a common cause of death, possibly due to the frequency of heavy snow avalanches that carry victims with them, causing major contusions. On the other hand, when some of these avalanches occur in times of light snow, engulfed victims hit rock outcroppings.

Figure 26.7. Victim management algorythm (by ICAR MedCom).


Conscious?
Yes
No
Suspect moderate hypothermia:
• Administer hot sugary drinks
• Change clothes if possible
Transfer to intensive care unit
Breathing? Is there a pulse?
Yes
No
Suspect severe hypothermia:
• Intubation and ventilation with hot moist air
• Transfer to hospital with extracorporeal circulation
Start CPR, intubate
Check the time buried and/or core temperature
≤ 60 min / ≥ 30 °C
Continue CPR
>60 min / <30 °C
Ventricular fibrillation
Asystole
ECG
Yes or doubtful
Suspicion of deep hypothermia
• Continue CPR
• Ventricular fibrillation: 1 shock test
• Transfer to hospital with cardiopulmonary bypass (If K⁺ >8 mmol/L, consider stopping the resuscitation)
Clear airway
No
Suspicion of suffocation
• lContinue CPR
• lTransfer to nearest hospital (If K⁺ >8 mmol/L, consider stopping the resuscitation; If K⁺ <8 mmol/L, transfer to hospital with extracorporeal circulation)

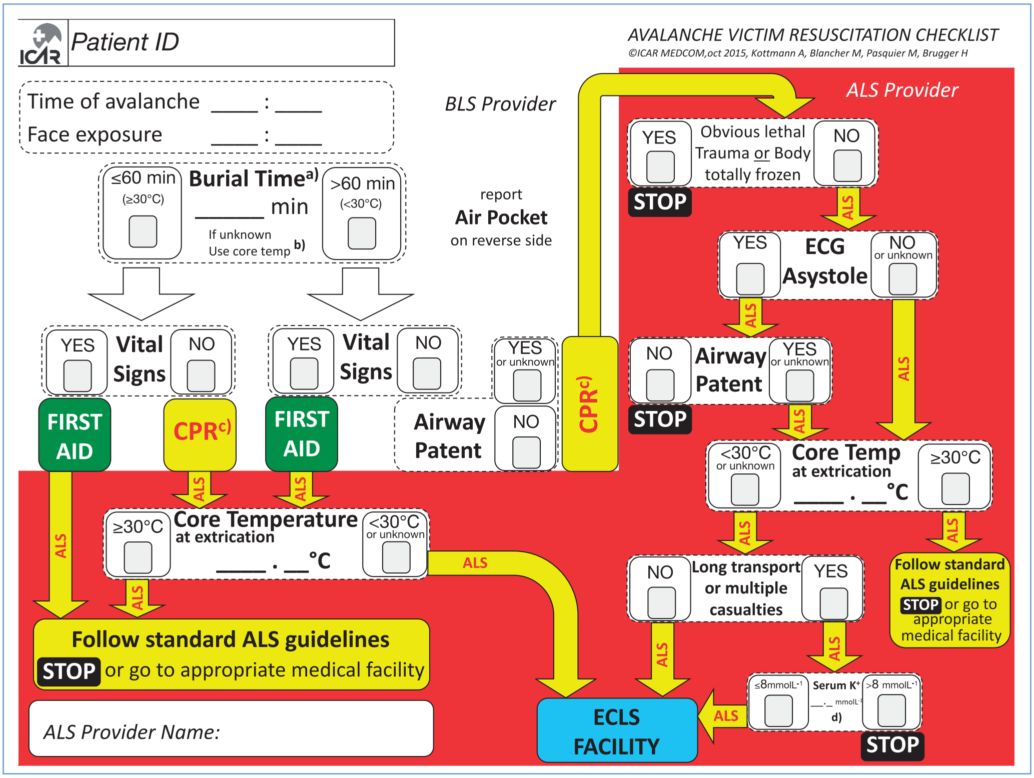
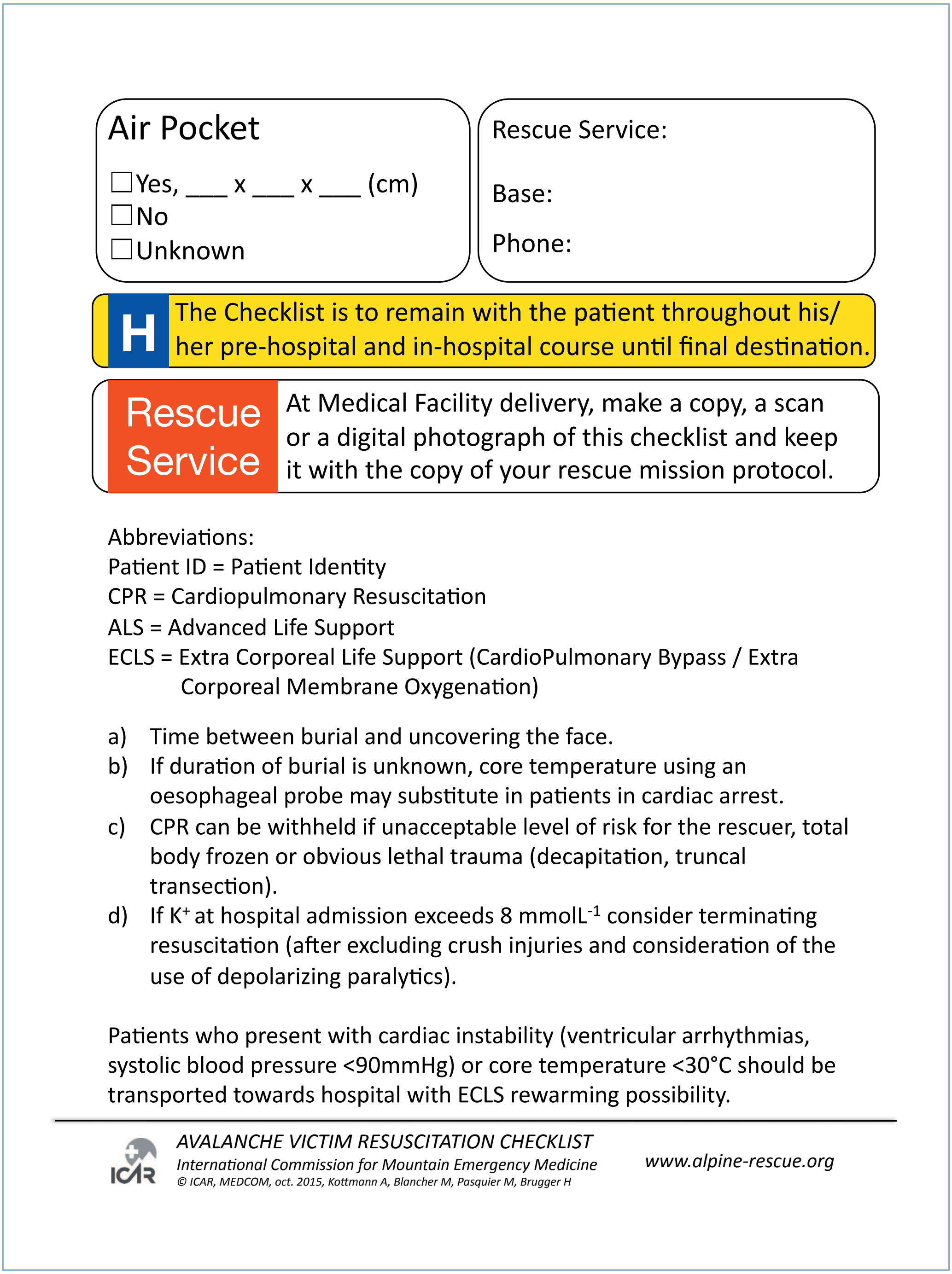

Patient ID
AVALANCHE VICTIM RESUSCITATION CHECKLIST
©ICAR MEDCOM,oct 2015, Kottmann A, Blancher M, Pasquier M, Brugger H
Time of avalanche ____ : ____
Face exposure ____ : ____
BLS Provider
ALS Provider
≤60 min (≥30°C)
Burial Time a)
______ min
If unknown Use core temp b)
>60 min (<30°C)
report Air Pocket on reverse side
YES
Vital Signs
NO
FIRST AID
CPR c)
YES or unknown
Airway Patent
NO
ALS
≥30°C
Core Temperature at extrication
_____ . __°C
<30°C or unknown
Follow standard ALS guidelines
STOP or go to appropriate medical facility
ALS Provider Name:
ECLS FACILITY
Obvious lethal Trauma or Body totally frozen
STOP
ECG Asystole
NO or unknown
Core Temp at extrication
Long transport or multiple casualties
Follow standard ALS guidelines
STOP or go to appropriate medical facility
≤8mmolL-1
Serum K+
__._ mmolL-1
d)
>8 mmolL-1

Figure 26.8a. Checklist for assessment of avalanche victims 1.



Air Pocket

☐Yes, ___ x ___ x ___ (cm)
☐No
☐Unknown

Rescue Service:

Base:

Phone:

H The Checklist is to remain with the patient throughout his/her pre-hospital and in-hospital course until final destination.

Rescue Service At Medical Facility delivery, make a copy, a scan or a digital photograph of this checklist and keep it with the copy of your rescue mission protocol.

Abbreviations:
Patient ID = Patient Identity
CPR = Cardiopulmonary Resuscitation
ALS = Advanced Life Support
ECLS = Extra Corporeal Life Support (CardioPulmonary Bypass / Extra Corporeal Membrane Oxygenation)

a) Time between burial and uncovering the face.
b) If duration of burial is unknown, core temperature using an oesophageal probe may substitute in patients in cardiac arrest.
c) CPR can be withheld if unacceptable level of risk for the rescuer, total body frozen or obvious lethal trauma (decapitation, truncal transection).
d) If K$^+$ at hospital admission exceeds 8 mmolL^{-1} consider terminating resuscitation (after excluding crush injuries and consideration of the use of depolarizing paralytics).

Patients who present with cardiac instability (ventricular arrhythmias, systolic blood pressure <90mmHg) or core temperature <30°C should be transported towards hospital with ECLS rewarming possibility.

AVALANCHE VICTIM RESUSCITATION CHECKLIST
International Commission for Mountain Emergency Medicine
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www.alpine-rescue.org

Figure 26.8b. Checklist for assessment of avalanche victims 2.

Section IV

ILLNESSES IN THE MOUNTAIN

CHAPTER 27
Illnesses in the mountain

CHAPTER 28
Clinical techniques

CHAPTER 29
Medical equipment

27 ILLNESSES IN THE MOUNTAIN

This chapter describes a series of symptoms and diseases whose diagnosis orientation and treatment is of interest to the mountaineer. In some cases, the interest lies in their frequency, and in others, in the seriousness they can pose if they are not suspected.

CHEST PAIN

Can have multiple causes: heart, lung, pleura, oesophagus, mediastinum, breast, musculoskeletal structures of the chest, neck or shoulder, upper abdominal viscera, psychic, etc. Pain intensity does not correlate with severity.[366]

The pain can be:

- Recurrent, sudden onset and moderate intensity with sudden exacerbations.
- Intense and prolonged, usually associated with acute episodes.

Recurrent chest pain

- Angina pectoris: this is the most important cause, although it is not the most frequent.
- Musculoskeletal pain is the most common cause. It may come from the musculoskeletal structures of the chest, neck, or shoulder. It is usually a pain that is not oppressive, not influenced by exercise, located in the wall, reproducible on palpation and localised to the left hemithorax (the presence of 4 of these symptoms/signs has a OR + of 1.8, the presence of 5 symptoms/signs a OR + of 3.8).[367] It causes the patient to breathe superficially and avoid coughing, favouring the retention of secretions that may be infected, so analgesics are administered (acetylsalicylic acid 500-1,000 mg, paracetamol 500-1,000 mg, or ibuprofen 400-600 mg every 4-6-8 hours **(A)** and deep breathing and abundant water are recommended. Treatment in most cases consists of rest, analgesics, localised heat and, subsequently, adequate physical exercise and correction of bad posture.
- Anxiety: pain is not related to exertion and is accompanied by a feeling of choking with sighs and hyperventilation.
- Reflux esophagitis: retrosternal pain that can be triggered by heavy and bounteous meals and alcohol intake. It increases when lying down and improves when standing up or with antacids.
- Others: herpes zoster, etc.

Prolonged and intense chest pain

- Acute myocardial infarction.
- Pericarditis: a common cause is viral infection. The pain is located in the centre of the chest, improves with sitting and leaning forward, and gets worse with breathing and decubitus. There may be tachypnea, non-productive cough, fever and tiredness. Pericardial friction may be heard during auscultation. Treatment: if acute viral pericarditis is suspected, Treatment may be started with 750-1000 mg acetylsalicylic acid every 8 hours for 10-14 days, or ibuprofen 600-800 mg every 8 hours **(A)** and absolute rest until a definitive diagnosis is obtained.
- Pneumothorax: a collection of air in the pleural space that causes a complete or partial collapse of a lung. It may be due to chest trauma, but may also occur spontaneously in healthy adults aged 20-40 years of age. The pain is of sudden onset,

increases with breathing and is accompanied by shortness of breath. During the examination, vesicular murmur decreases or disappears during auscultation, tachypnea, tachycardia, asymmetric expansion of the affected hemithorax, and increased resonance at percussion. The definitive diagnosis is radiological. Treatment depends on the extent of the pneumothorax. If it is small, it only needs bed rest and observation. If it is large, it should be drained.

- Pleural pain secondary to pneumonia or pleural effusion: worsens with coughing or deep breathing.
- Tracheobronchitis: a burning sensation along the trachea that increases with coughing.
- Other causes: aortic dissection, pulmonary thromboembolism, gastroduodenal ulcer and cholecystitis.

Coronary pain

If the coronary arteries become blocked, injury from myocardial hypoxia causes coronary pain (angina). If the obstruction is complete, an acute myocardial infarction may occur.

The pain is often related to exercise, emotional stress, heavy meals, and cold. It is more common in men over 35 or postmenopausal women, especially with risk factors (smoking, high blood pressure, high cholesterol, diabetes, obesity, sedentary lifestyles, alcoholism, or stress).

The pain usually starts behind the breastbone, radiating to the back, arms, shoulders, teeth, or abdomen. It may be constraining or oppressive and does not increase with movement or breathing. No pain on palpation (OR – 0.23 (0.15-0.41)). May be accompanied by a vegetative syndrome (cold sweating, nausea, vomiting). It is a constant pain and the patient

Table 27.1. Probability ratios of occurrence of anamnesis and physical examination in the diagnosis of thoracic pain[367]

	Symptom / manoeuvre	OR +	OR –
Musculoskeletal	Presence of 5 symptoms (a)	3.8	0.47
	Score scale >2 (b)	3.02	0.47
Gastroesophageal reflux	Pain that worsens with ingestion	10.5	-
	Retrosternal irradiation	6.39	-
Gastrointestinal	Pain that worsens with ingestion	21	-
	Vomiting	4.5	-
	Retrosternal pain	5.25	-
Aortic dissection	Sudden onset of pain	1.6 (1-2.4)	0.3 (0.2-0.5)
	Pulse disturbance	5.7 (1.4-23)	0.7 (0.6-0.9)
	Focal neurological deficit	33 (2-549)	0.71 (0.6-0.9)
	Pain referred to as a tear	10 (1.37-80)	0.9 (0.87-0.97)
Pleural effusion	The asymmetrical mobility of the chest	8.1 (5.2-12.7)	0.29 (0.19-0.45)
	Dull to percussion	8.7 (2.2-33.8)	0.31 (0.03-3.3)
	Decreased vocal vibrations	5.7 (4-8)	0.21 (0.12-0.37)
	Dullness in auscultation	7.7 (2.4-25.1)	0.27 (0.07-1)
	Hypoventilation	4.3 (2.8-6.6)	0.64 (0.54-0.76)
	Pleural friction	3.9 (0.8-18.7)	0.96 (0.9-1)

(a) Non-oppressive pain, pain not influenced by exercise, localised in wall, localised in left hemithorax, reproducible on palpation.

(b) 1 point for each sign/symptom: localised muscle tension, stabbing pain, pain on palpation, no coughing.

is usually still. Calms down with rest and sublingual nitrites in a few minutes. If it lasts less than 15 minutes, it is usually angina pectoris or angina. If it lasts longer than 20 minutes, it may mean we have a prolonged angina or acute myocardial infarction.

Prehospital pain treatment (A)

- Rest.
- Administer sublingual nitrites, if there is no hypotension, warn not to swallow saliva for at least one minute. A second or third dose may be repeated if the pain does not improve within three minutes and send the patient to hospital.
- Acetylsalicylic acid 150-300 mg if there is no allergy or digestive intolerance to aspirin.
- Oxygen achieve SpO_2 94-98%.
- Treatment of pain with morphine hydrochloride trihydrate.
- Transfer to hospital.

ACUTE ABDOMINAL PAIN

Abdominal pain is a common reason for urgent consultation. In more than 50% of the cases, a first outpatient diagnosis is not made. Non-specific abdominal pain usually progresses favourably.

Behaviour towards urgent abdominal pain

- Anamnesis: history, how the pain began and its characteristics.
- Rapid scan, looking for signs of extreme severity (pulse, blood pressure).
- Treat shock.
- Transfer to hospital.
- It is recommended to avoid the administration of analgesics or sedatives until a diagnosis has been made or the therapeutic attitude has been decided. However, since severe abdominal pain can cause vasovagal reactions (cold sweating, nausea, vomiting) and anxiety during transport, analgesics are sometimes given to suppress symptoms, even if this involves supplementing the physical examination biased by analgesia with additional tests (ultrasound or abdominal CT scan).

Abdominal pain can be caused by extra-abdominal pathology: pneumonia, myocardial infarction of the lower face, etc.

Table.27.2. Signs and relevance of findings in abdominal exploration[368]

Exploratory manoeuvres	OR + indicative of abdominal pathology
Abdominal stiffness	3.9 (peritonitis)
McBurney point	8.4 (appendicitis) (OR – 0.1)
Obvious and visible intestinal peristalsis	18.8
Abdominal distention	9.6
Auscultation: overactive abdominal sounds	5
Abnormal bowel sounds	3.2
Signs of detection of peritonism and abdominal stiffness	3.9

Differential diagnosis of sudden onset specific abdominal pain

- Ischemic heart disease: non-sensitive abdomen, epigastric pain, history of coronary heart disease, vegetative syndrome (cold sweating, nausea or vomiting), etc.
- Mesenteric infarction or angina: intense pain in the centre of the abdomen, diffuse, bloody stools, feeling of severity, shock.
- Perforation of a gastroduodenal peptic ulcer: history of ulcer or difficult digestion, abdominal contracture, sudden onset and later diffuse epigastric pain.
- Acute pancreatitis: pain in the left upper quadrant or upper hemiabdomen around a belt, which may radiate to the shoulder or back. History of wind or biliary lithiasis.
- Hepatic colic: pain in the right upper quadrant, irradiating to the right shoulder and back; sometimes nausea, vomiting and diaphoresis. History of similar episodes or fat intolerance. No fever or peritonitis. It occurs after a significant intake. Emergency treatment: ibuprofen 400-600 mg or diclofenac 50-75 mg **(A)**.
- Nephritic colic.

- Ectopic pregnancy: severe, persistent pain in the lower central abdomen, sometimes with significant pallor and signs of shock.
- Incomplete fractured abdominal aortic aneurysm: abdominal and lumbar pain associated with signs of shock.

Differential diagnosis of gradual onset specific abdominal pain

- Acute cholecystitis: localised pain as in hepatic colic but less intense, continuous, with lack of appetite and nausea, fever with peritoneal irritation. History of gallstones, intolerance to fats. Jaundice may be present. Pain on palpation of the lower edge of the liver.
- Intestinal obstruction of the small intestine or colon: intermittent colic pain, abdominal distention, tympanism. Peristaltic struggling noises. If the obstruction is low, the symptoms are more covert. Within 12-24 hours of the onset of the obstruction, the bowels are so distended due to fluid and air that the contractions stop and the noises disappear. At this stage, signs of peritonitis may appear: diffuse abdominal pain and tenderness to the touch. One or two stools may be present at the beginning of the obstruction, but diarrhoea is rare. The presence of strangulated inguinal hernia should be ruled out, and if it exists, an attempt should be made to reduce it. To do this, the patient is placed on their back, with the head and chest lower than the abdomen, so that the force of gravity helps the bowel return to the abdominal cavity. The patient is asked to relax, and moderate but constant pressure is applied to the herniated area for 10 or more minutes, to allow the intestinal mass to return to the abdominal cavity.
- Acute appendicitis: pain in the right iliac fossa with abdominal contracture and signs of peritoneal irritation.
- Mesenteric adenitis: swollen glands in the lower right quadrant of the abdomen. It is associated with upper respiratory tract infections.
- Acute pneumopathy affecting the diaphragmatic pleura: increased pain when coughing, no abdominal hypersensitivity.
- Diverticulitis: colic pain usually located in the lower left quadrant. There may be bloating, hypersensitivity, and fever.
- Acute gastroenteritis: mild cramping, poorly localised pain, nausea, vomiting, diarrhoea, diffuse abdominal hypersensitivity, hyperperistalsis. There may be muscle defence.

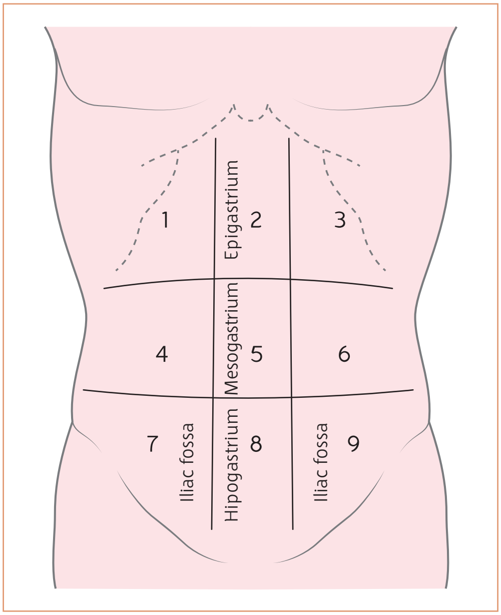

Figure 27.1. Zones of the abdomen.

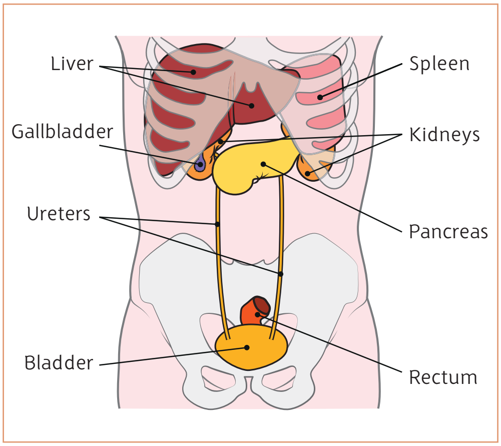

Figure 27.2. Organs of the abdomen.

- Acute hepatitis: jaundice, choluria, pain in the right upper quadrant of the abdomen, no signs of peritoneal irritation.
- Pelvic inflammatory disease and acute salpingitis: severe cramping in the lower abdomen and fever. History of recent sexual intercourse, IUD, or abortion.

Table 27.3. Organ affected by the location of the pain

Epigastrium	Mesogastrium	Hypogastrium
Stomach. Duodenum. Gallbladder. Pancreas. Lower oesophagus.	Small intestine. Caecal appendix. Right and transverse colon.	Urinary bladder. Uterus, tubes and ovaries. Sigmoid colon.

Table 27.4. Shifting of the pain according to its origin

Origin	Shifting
Gallbladder. Pancreas. Posterior duodenal ulcer.	From epigastrium to back.
Gallbladder.	Shoulder and scapula to the right and back.
Functional pathology of the colon.	Towards the upper and lower left hemiabdomen.
Pancreas. Malignant peritoneal disease.	From the umbilical region to the back.
Kidneys, ureters. Sigmoid diverticulitis. Ovary and tubes.	To inguinal regions.

Acute abdominal pain

This is a set of clinical pictures characterised by abdominal pain of with less than one week of evolution and which, due to their severity, are subsidiary to medical-surgical treatment. The diagnosis is very often clinical. The most common cause is acute appendicitis.

It can be grouped into three major syndromes:

- Obstructive syndrome: intestinal obstruction causes colicky pain, vomiting, and bowel closure. The patient is agitated and may have abdominal distention. There is hyperperistalsis to auscultation. There may be dehydration and no fever at first.
- Peritonitis is inflammation of the membrane that lines the abdominal cavity. It produces continuous, intense pain, which forces the patient to bed and immobilises them, as movements are very painful. Reflex vomiting, high fever, abdominal contracture and paralytic ileus. The administration of analgesics and antibiotics is evaluated during the evacuation.
- Ischemic syndrome: mesenteric ischemia causes pain that is often sudden, continuous and intense, poorly localised, accompanied by vomiting, reflexes and little symptomatology at first.

Acute appendicitis

Abdominal pain of central onset, of varying intensity and characteristics, which then radiates and is located in the right lower quadrant of the abdomen. In 30% of patients, the pain begins in this quadrant. It rarely occurs in the lower back. It is peritoneal, continuous, and it worsens with movement and coughing. If it is due to a faecaloma obstruction, the pain is colicky. Vomiting occurs frequently and is associated with loss of appetite and constipation, but in 30% of patients there may also be diarrhoea.

Examination: there is often a moderate fever with a difference of more than 1 °C between the axillary and rectal temperatures. Pressure pain in the lower right quadrant, accompanied by muscle defence or contracture. Decompression pain is present in 80% of cases, a sign also found in 20% of the non-specific abdominal pain cases. The rectal exam causes pain on the right side of the recto-uterine (Douglas') pouch.

Differential diagnosis with non-specific abdominal pain: there is no shifting of pain from the central abdominal area to the lower right quadrant. The pain does not increase with movement or coughing. Pain is less frequent when pressure is applied, there is usually no defence or contracture and no pain when decompression is applied. There is no pain on rectal palpation.

Unlike gastroenteritis, there is no history of eating spoiled food that could also infect other members of the group, pain is localised and constant, without cramping, and diarrhoea is rare.

Treatment: if evacuation is not possible in less than six hours, start antibiotics for 10 days. Cefotaxime 2 g/12 hours followed by Tinidazole 800 mg/day for two days intravenously, followed by Ofloxacin 200 mg/12 hours and Tinidazole 500 mg/12 hours orally for 8 days **(A)**. Fluoroquinolones should be reserved for use in patients who have no alternative treatment options. Acute appendicitis treated with antibiotics has a recurrence of 20%.[369, 370 371.]

If conservative treatment is chosen and after a few days (5-15 days) a tumour is felt in the lower right quadrant with muscular defence, there is a feeling of severity, spiking fever and chills, suspect an appendicular abscess that must be drained. Unlike appendicular abscess, an appendicular plastron does not require drainage, the latter occurs in a similar way, but with less pain, without high spiking fever and without as much sensation of severity.

Priority evacuation for abdominal pain

In the mountains, a distinction must be made between abdominal pain that requires urgent evacuation and surgical treatment, and pain that does not.

Signs and symptoms that point to an acute abdominal problem, possibly surgical, that requires urgent evacuation

- Severe pain that lasts more than six hours and prevents sleep in a person who was previously fine.
- Abdomen distended with vomiting.
- No gas in the abdomen.
- Increased pain on abrupt removal of the hand, muscle defence (contracture on palpation of the painful area), or maximum abdominal rigidity (persistent contracture) indicate possible peritoneal irritation.

Abdominal pain that usually does not require immediate evacuation or urgent surgical treatment

- Gastroenteritis.
- Menstrual pain or pain related to ovulation: paracetamol 500 mg may be given every 6-8 hours or ibuprofen 400 mg every 8-12 hours.
- Nephritic colic: ibuprofen 400 mg may be administered every 8-12 hours.
- Urinary tract infection.

Peritonitis usually develops with the abolition of peristalsis; gastroenteritis, mechanical ileus and sub occlusion develop with increased peristalsis.

Side stitch

Flatus manifests itself as a sharp pain in the side, usually stabbing, during physical exercise.

The popular myth attributes flatus to an accumulation of gas in the stomach caused by an increase in breathing rate or the ingestion of water or food during physical exercise. However, the real cause appears to be a lack of blood supply to the respiratory muscles, caused by overexertion or poor physical preparation, which in turn causes the individual to increase their breathing rate.

Prevention

- Training, in the medium term, favours the absence of flatus.
- Do not eat 3-4 hours before an exercise session.
- Avoid foods that are high in sugar, fat, and salts.
- Drink a lot, but in small sips, and never carbonated drinks.
- Run with smooth strides when running downhill and without sudden movements.

Treatment

- When flatus appears, it is best to reduce or stop physical exercise. The flow of oxygen to the muscles that caused the pain will return to normal and the pain will go away.
- Bend forward and press down, massaging the painful area.
- Take deep breaths with forced expirations, decreasing the breathing rate.
- Breathe against resistance, tightening your lips to make it hard to get the air out.

ANAL PAIN

Anal fissures

These are small tears at the edges of the anus caused by the passage of hard, bulky stools.

Signs and symptoms

Pain with bowel movements that persists after bowel movements and is often accompanied by bleeding at the end of bowel movements.

Treatment

- Avoid constipation: drink plenty of water, don't suppress the desire to defecate, diet high in fibre: fruit, vegetables, cereals, etc. **(A)**. If necessary, add laxatives **(C)**.
- Avoid friction injuries: do not use coarse toilet paper, but use moist towelettes **(C)**.
- Warm water **(B)**, analgesia (paracetamol 0.5-1 g every 4-6 hours, ibuprofen 400 mg every 8-12 hours) **(C)** or local anaesthetic ointment (urological lubricant).
- Decubitus rest.

Haemorrhoids

Dilated veins of the anus that can become congested and bleed.

Signs and symptoms

- Itching and heavy feeling.
- Bleeding may occur during defecation.
- Pain. If the pain is severe and there is a hard nodule, haemorrhoidal thrombosis must be suspected, which sometimes requires surgical debridement.

Treatment

- Avoid constipation: drink plenty of water, don't suppress the desire to defecate, diet high in fibre: fruit, vegetables, cereals, etc. **(A)**. If necessary, add laxatives.
- Avoid friction injuries: do not use coarse toilet paper, but use moist towelettes **(C)**.
- Anti-haemorrhoidal and anti-congestive ointment, analgesia (paracetamol 0.5-1 g every 4-6 hours, ibuprofen 400 mg every 8-12 hours) and sitz baths with warm water **(C)**.

Perianal abscesses

Abscesses that have their origin in the glands of the anorectal dentate line and that protrude into the perianal region.

Signs and symptoms

- Pain and induration on one or both sides of the anus with a tendency to extend to the buttocks. Redness of the area may be associated.
- If they debride spontaneously, a hole appears on the oozing indurated surface.

Treatment

- The most effective treatment to relieve pain is debridement, under local or general anaesthesia, which reduces the tension of the area and, therefore, the pain.
- Alternatively, antibiotics may be given (amoxicillin with clavulanic acid 500 mg every 8 hours), as may analgesics and anti-inflammatory drugs (ibuprofen 400 mg every 8-12 hours).

Sacral pilonidal cysts or sinuses

Abscesses in the area of the intergluteal cleft 4-5 cm above the anus.

Signs and symptoms

Localised inflammation zone but with a tendency to spread if not treated early.

Treatment

- The most effective treatment to relieve pain is debridement under local or general anaesthesia, which reduces the tension in the area and, therefore, the pain **(C)**.
- Alternatively, antibiotics may be given (amoxicillin with clavulanic acid 500 mg every 8 hours), as may analgesics and anti-inflammatory drugs (ibuprofen 400 mg every 8-12 hours).

FEVER

Fever is an increase in axillary temperature above 37 °C. It is a reaction of the organism against several causes. Although strenuous exertion can cause fever, the most common cause is an infection.

The most frequent causes in mountains are:

- Upper respiratory tract infection: common cold, pharyngitis, etc.
- Pneumonia.
- Urinary tract infection.

Treatment of a patient without febrile focality

- Temperature control every 6 hours.
- Sufficient oral hydration and carbohydrates.
- Decrease fever with a 500 mg dose of a paracetamol-type antipyretic, or acetylsalicylic acid, every 6 hours. Avoid acetylsalicylic acid in case of allergy, asthma or duodenal ulcer **(A)**.
- Transfer to hospital for diagnosis.

VOMITING

Is a reflex action by which the gastric contents are expelled abruptly through the mouth. It is a manifestation of functional or organic disorders. Cause must be diagnosed: inflammatory, obstructive or reactive.

Treatment

- If the vomiting is of banal cause and is persistent, pharmacological treatment with ondansetron can be administered 4-8 mg before meals **(A)**.
- If the cause is motion sickness, antihistamines may be given: diphenhydramine 25 mg every 8 hours **(A)**. As a precaution, it can be taken one hour before the start of the trip. Dizziness improves when movement is reduced, so it is advisable to sit in the front seat of cars, in the wing area of airplanes or in the central area of boats.

ACUTE INFECTIOUS GASTROENTERITIS

This is a diarrhoeal condition, with less than two weeks of evolution, which can be accompanied by nausea, vomiting, abdominal pain and fever, usually self-limiting, but which can lead to serious complications secondary to dehydration or sepsis.

Classically, two types of diarrhoea are distinguished:

- Coleriform: by enterotoxin, profuse watery diarrhea that can quickly dehydrate.
- Dysenteriform: due to inflammatory lesions of the mucosa, there is fever, abdominal cramping, rectal urgency and blood, mucus and pus in the stool.

Table 27.5. Clinical classification of diarrhoea

Mild	Moderate-severe
Less than four bowel movements a day. Mild or absent abdominal pain. Absence of fever and dehydration. Absence of rectal bleeding.	More than four bowel movements a day. Moderate to severe abdominal pain. Fever and/or dehydration. Rectal bleeding.

Prevention

To reduce the risk of acute gastroenteritis, the aphorism “boil it, cook it, peel it, or don’t eat it” is useful. It is advisable to take these precautions with any food: water, fruit, seafood, meat, ice cream, ice cubes and, depending on the environment, even with the water for brushing your teeth.

Treatment (A)

- Hydration: solutions with carbohydrates (rice or carrot water) and electrolytes are recommended. Diet: during the first 24 hours give only hydrating solutions; later it is usually advisable to abstain from milk and food with lactose for 2-3 weeks due to frequent lactose malabsorption, secondary to infectious gastroenteritis.
- Symptomatic: analgesics (paracetamol) and antiemetics (ondansetron) can be used. The use of antidiarrheals (loperamide) is controversial, as they may lengthen the duration of the infectious process by slowing the passage of the poison and masking more severe colitis, but may be used in mild to moderate cases (without fever or bloody diarrhea). They are contraindicated in severe cases where enteroinvasive microorganisms are suspected
- Empirical antibiotic therapy: as a general rule, is not indicated in mild cases.
- If the condition is severe, with dehydration or symptoms suggestive of sepsis, or if the

patient does not tolerate intake, hospital admission should be assessed.

RESPIRATORY PATHOLOGY

Common cold

The common cold is a contagious, benign, self-limiting viral infection of the respiratory tract.

Signs and symptoms

Fever not exceeding 38-39 ºC, general malaise, headache, myocardialgia, fatigue. There may be nasal congestion, runny nose, coughing, sneezing. Cures in 4-7 days, although the cough may persist for another 15 days.

Possible complications: sinusitis, otitis, pharyngitis, laryngitis, tracheobronchitis, pneumonia. Complication is suspected if the process is slow to resolve, if mucopurulent discharge, earache, or difficulty breathing occurs.

Treatment (C)

- Antipyretic (paracetamol or acetylsalicylic acid 500 mg every 6 hours).
- Bed rest if possible.
- Drinking plenty of fluids.
- Light diet.
- Nasal washes with saline solution, gargling and water vapour inhalation.
- Antitussives: if the coughing is very intense, non-productive and does not allow sleep, codeine 10-30 mg can be administered every 6-8 hours. May cause constipation, vomiting and drowsiness.
- Antibiotics: only indicated in case of bacterial over-infection.

Tracheobronchitis

Is usually viral. In healthy adults, tracheobronchitis is self-limiting and cough may persist for 15 days.

Treatment (A)

- Analgesics - antipyretics (paracetamol, acetylsalicylic acid 500 mg every 6 hours), avoid smoking and cold, drink plenty of fluids and inhale water vapour.
- Antitussives: if coughing is very intense, non-productive and does not allow sleep, codeine 10-30 mg can be administered every 6-8 hours. It may cause constipation, vomiting and drowsiness.
- Antibiotics: only indicated in case of bacterial over-infection.

Pneumonia

Is a lung infection. Below are the two most common types that occur in people who are usually healthy, such as mountaineers.

Pneumococcal pneumonia

Is the most common bacterial pneumonia. It may occur after an upper respiratory tract cold. The onset is acute, with chills, fever, pleuritic pain (increases with breathing), tachypnea (OR + 1.2-3.4), cough, mucopurulent or bloody sputum.

Treatment

Amoxicillin 1 g every 8 hours for 7-10 days. If allergic, levofloxacin 500 mg can be administered every 12-24 hours for 10 days **(A)**.

Mycoplasma pneumonia

More frequent in young people. Insidious onset, preceded by tracheobronchitis with dry cough or low mucopurulent expectoration. It does not usually cause pleuritic pain or chills. Fever below 39 °C. Severe headache.

Treatment

Clarithromycin 500 mg every 12 hours for 10 days **(A)**.

Symptomatic treatment

Analgesic-antipyretics (paracetamol, acetylsalicylic acid 500 mg every 6 hours), abundant hot liquids **(C)**.

An alternative empirical treatment for pneumonias is levofloxacin 500 mg/day for 7-14 days. **(A)**.

Asthma

Asthma is a disease characterised by an abnormal sensitivity of the bronchi to various stimuli that causes a disseminated narrowing of the bronchial tree. Active asthma is a relative contraindication for stays at altitudes above 3,000 m.

Stress asthma is the transient increase in airflow resistance in the airways due to increased ventilation after vigorous exercise. Asthma attacks peak 5-15 minutes after exercise and resolve spontaneously after 20 minutes. Inhalation of cold, dry air, common in the mountains, stimulates bronchospasm caused by exercise, while warm, moist air inhaled while swimming at the beach is better tolerated by asthmatics.[372]

Diagnosis

- Cough.
- Dyspnoea.
- Wheezing at rest (OR + 38 (29-49)).
- Sibilants (OR – 0.3 (0.2-0.4)).
- Chest tightness or thoracic tension.

They can occur together or separately and are very characteristic at night or in the early morning. They usually occur after exercise or from exposure to triggers (dry cold triggers more bronchial spasms than moisture).

Table 27.6. Performance of signs and symptoms in the diagnosis of asthma[373]

Symptoms	OR +	OR –
Self-declared asthma	20	0.6
Wheezing with dyspnoea	13 (11-15)	0.4 (0.3-0.4)
Nocturnal dyspnoea	11 (9.7-14)	0.6 (0.5-0.6)
Dyspnoea without coughing	10 (8.7-11)	0.4 (0.4-0.5)
Shortness of breath at bedtime	9.4 (8-11)	0.6 (0.5-0.6)
Sibilants	5.9 (5.4-6.5)	0.3 (0.2-0.4)
Night-time chest tightness	3.5 (3-4)	0.6 (0.5-0.6)
Exercise dyspnoea	2.9 (2.6-3.2)	0.4 (0.3-0.5)
Combinations		
Sibilants and dyspnoea at rest	38 (29-49)	0.6 (0.6-0.7)
Wheezing and nocturnal dyspnoea	37 (28-48)	0.6 (0.6-0.7)
Wheezing and night time chest tightness	37 (28-48)	0.6 (0.6-0.7)

Table 27.7. Degree of severity of asthma exacerbations

Manifestations	Mild	Moderate	Severe	Extremely severe
Suffocation.	Walking around.	Talking.	At rest.	Cyanosis (bluish skin and lips).
Respiratory rate normal: 12-20 per minute.	Normal or increased.	Increased.	> 30/minute.	>30/minute Impaired consciousness.
Use of accessory muscles.	No.	Usual.	Usual.	Failure signs.
Pulse.	<100/minute.	100-120/minute.	120/minute or bradycardia.	Bradicardia or hypotension.
Wheezing.	Moderate.	Severe.	Severe or absent.	Auscultatory silence.

Complementary tests: spirometry with bronchodilator test or bronchoprovocation with methacholine.

Emergency treatment (A)

- Exercise asthma: short half-life adrenergic B2 bronchodilator, 2 puffs 15 minutes before exercise (salbutamol, terbutaline, formoterol). Intense, long-lasting warm-up (>15 minutes) before activity and progressive cooling at the end of activity in cold environments reduces crises.
- Crisis: short half-life adrenergic β2 bronchodilator, 4-6 puffs when needed (salbutamol, terbutaline, formoterol). Once the initial dose has been administered and depend-

ing on the severity, the 6-pulse dose can be repeated once or twice, with an interval of 30 minutes.

- In moderate or severe crises, corticosteroids can be added: 0.5-1 mg/kg/day of methylprednisolone via IM or IV.
- Oxygen therapy if necessary to maintain SpO_2 94-98%.
- If the patient does not return to normal within 30 minutes or if it is severe, they should be transferred to hospital.

OPHTHALMIC EMERGENCIES[146, 147]

Ocular traumas

- **Subconjunctival haemorrhages:** a small haemorrhage can be observed in the eye, without pain or alteration of vision. It may occur spontaneously, or after an attack of coughing or vomiting, or it may be due to trauma. It resolves spontaneously in 1-2 weeks.
- **Superficial wounds of the eyeball:** corneal erosions cause severe pain, photophobia, and tearing. They are treated with irrigation, cyclopentolate hydrochloride (Cyclogyl), antibiotic ointment, anti-inflammatory and control by the ophthalmologist. **(A)** Eye rest (avoid work that involves significant eye movement) and sunglasses are recommended if photophobia is present. There are no advantages in placing an occlusive patch on corneal abrasions, and it may also delay the epithelisation[374] **(A)**.
- **Superficial foreign bodies:** cause severe, sharp eye pain, tearing, photophobia and congestion. If the foreign body is on the conjunctiva and not embedded, it can be removed with a damp cotton pad. If it is hidden, the upper eyelid can be everted: the patient is asked to look down, pull the eyelashes with one hand while the other hand applies a cotton swab or match stick to the fold that forms the skin with the eyelid; it is pulled downwards with the latter while the first hand pulls the eyelashes upwards. This procedure allows the inner surface of the upper eyelid to be seen well, allowing the foreign body to be removed. Antibiotic ointment is then applied. Placing an occlusive patch is not indicated **(A)**.

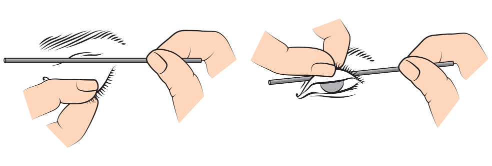

Figure 27.3. Eversion of the eyelid.

- **Penetrating trauma:** Wash the wound with saline solution, apply an antibiotic ointment, use analgesics if necessary and refer to an ophthalmologist **(A)**.

Acute conjunctivitis

Is an inflammation of the conjunctiva, usually of an infectious or allergic cause.

Signs and symptoms

Diffuse redness, itching, a stinging or sandy-eyed sensation in the eyes, tearing and purulent discharge from the anterior pole of the eye in case of infection, absence of pain and little discomfort with light. Vision is not blurred.

If there is photophobia and pain, suspect the presence of inflammation of the cornea (keratoconus conjunctivitis).

Treatment

- If an infectious cause is suspected, treat it with antibiotic eye drops every 1-2 hours for the first 2-3 days and every 4 hours thereafter, and antibiotic ointment at night for up to 48 hours after the symptoms subside **(A)**.
- Do not share a tissue or towel and wash your hands to avoid infection **(C)**.
- If allergic, apply antihistamine eye drops, 1 drop in each eye every 12 hours, and oral antihistamines (cetirizine, ebastine, loratadine), 1 drop every 24 hours.

Stye

A stye is the swelling of a sebaceous gland.

Treatment (A)

- Warm compresses every 4-6 hours and antibiotic ointment.

DENTAL ABSCESS

Is an infection in the root of a tooth. It is usually very painful.

Treatment (A)

- Antibiotic: amoxicillin with clavulanic 875/125 mg every 12 hours for 7-10 days. For allergy sufferers: clindamycin 300-450 mg every 8 hours.
- Analgesics (paracetamol or acetylsalicylic acid 0.5-1 g every 6-8 hours) or anti-inflammatories (ibuprofen 400-600 mg every 6-8 hours).
- Visit the odontologist.

DISLOCATED JAW

It occurs when eating.

Treatment

Pad both thumbs to avoid being bitten during reduction. Place both thumbs on the patient's last lower molars and press down.

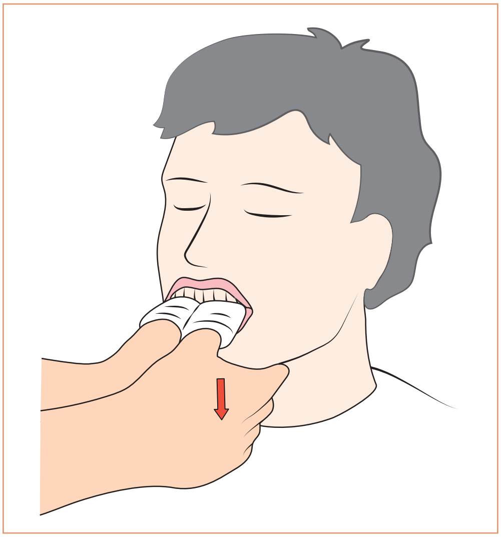

Figure 27.4. Luxation of jaw.

OTORHINOLARYNGOLOGICAL EMERGENCIES

Allergic rhinitis

A nasal allergy usually caused by pollen, dust, or other allergens in the air.

Signs and symptoms

Runny nose with watery secretion and sneezing.

Treatment (A)

- Inhaled antihistamines (azelastine, levocabastine), 1 inhalation every 12 hours.
- For intermittent, or persistent moderate-severe allergic rhinitis: inhaled nasal corticosteroids (dexamethasone, beclomethasone, budesonide, mometasone, fluticasone, triamcinolone).
- Oral antihistamines (cetirizine, ebastine, loratadine), 1 every 24 hours, if necessary.

Sinusitis

Is an infection of the sinuses, which are air-filled spaces located inside the bones of the face and covered by a mucous membrane similar to that of the nose. They are connected to the nose through very fine channels.

Sinusitis is almost always caused by a blockage of the sinus drainage channels as a result of tumefaction of the mucous membrane surrounding the openings, due to cold or allergy. Mucus collects inside the sinuses and becomes infected.

Signs and symptoms

Headache, usually frontal retro orbital. There may be fever, purulent rhinorrhoea (OR + 5.5) and oedematous nasal mucosa (OR – 0.13). The affected sinus may be tender to palpation.

Treatment (A)

- Antibiotics (amoxicillin with clavulanic acid 875/125 mg every 12 hours or, in case of allergy, clarithromycin 500 mg every 12 hours, levofloxacin 500 mg every day for 10 days.
- Analgesia (paracetamol 0.5-1 g every 6-8 hours or ibuprofen 400-600 mg every 6-8 hours).

Pharyngotonsillitis

50% are viral. The main bacterial cause is streptococcal.

Signs and symptoms

Sore throat, difficulty swallowing, fever of 39 °C or more, reddened pharynx, yellowish exudate covering the tonsils (OR + 3.4 (1.8-6)) and posterior pharynx, enlarged and painful submandibular and cervical adenopathies. Scarlet fever may be present. May be accompanied by headache, dizziness, myalgia and anorexia.

Treatment

- In patients younger than 30 years of age, in case of suspected haemolytic group A streptococcal B pharyngitis, antibiotic treatment is important to prevent rheumatic fever. Penicillin G benzathine 1,200,000 IM in a single dose. If the IM route is not used, 10 days of oral amoxicillin treatment with 500/125 mg clavulanic acid should be completed every 12 hours. If allergic, take clarithromycin 500 mg daily for 5 days **(A)**.
- Analgesia (paracetamol 0.5-1 g every 6-8 hours or ibuprofen 400-600 mg every 6-8 hours) **(C)**.

Otalgia

The patient with an atrial pathology may consult for pain, heartbeat, tinnitus, dizziness, deafness or suppuration. The pain may be caused by otitis or radiated from other areas (dental injury, neuralgia, etc.).

In addition to treating the cause, analgesia may be given with paracetamol or acetylsalicylic acid, and codeine if associated with severe pain.

External otitis

Is an inflammation of the skin of the outer ear or ear canal. The most common is the acute diffuse external otitis infection.

Signs and symptoms

Initial itching, severe pain, sticky, yellowish secretion, feeling as if the ears are clogged up and with hearing loss, frequent retroauricular adenopathy. Fever can reach up to 40 °C. Pressure of swallowing, rubbing the ear or chewing can make the pain worse.

Treatment (A)

- Corticoid drops and local antibiotics may be given for 7 days if there is no tympanic perforation.
- If tympanic perforation exists, topical fluorquinolones (topical otic ciprofloxacin) are preferable, although their ototoxic potential is not known with certainty.
- In precarious situations, some authors recommend placing a gauze moistened with a couple of drops of vinegar, due to its acidifying power.

Acute otitis media

Is a middle ear infection.

Signs and symptoms

Intense and constant ear pain, deafness may occur. When spontaneous perforation of the tympanic membrane occurs, a bleeding secretion may appear while the pain subsides.

Treatment (A)

- Amoxicillin with clavulanic acid 875/125 mg every 12 hours or, in case of allergy, clarithromycin 500 mg every 12 hours, levofloxacin 500 mg every day for 10 days.
- Analgesia (paracetamol or acetylsalicylic acid 0.5-1 g every 6-8 hours or ibuprofen 400-600 mg every 6-8 hours).

Foreign bodies in the ear

If it is an insect, it should be eliminated by pouring mineral oil or lidocaine 2% in the ear. The extraction is done by washing with a 20 ml syringe filled with warm water. Washing is contraindicated if there are organic foreign bodies (seeds) that can swell with water, if the obstruction is total or if there is a previous pathology. No manoeuvres should be carried out that could further embed the object. If the patient has a history of recurrent otitis, the patient is referred to an otolaryngologist for an extraction.

Foreign bodies in the pharynx

Bones usually get stuck in the tonsils and can be removed by depressing the tongue with a gauze and using long tweezers. In some cases where they are impacted at a lower level, transferred the patient to hospital.

Epistaxis

May occur in the course of a nasal trauma, prolonged exposure to the sun, catarrhal process, arterial hypertension and other medical conditions, or spontaneously.

Treatment

Initially, practise local compression with a small cotton pad inside the external nostril, pressing the nasal sidewall against the nasal septum with the finger for 10-15 minutes. If it persists, an anterior tamponade is performed with a long, thin gauze band that is introduced into the nostril and left for 48 hours. In this case, antibiotics (amoxicillin with clavulanic acid 500 mg every 8 hours) should be administered to avoid infection. Avoid a dry environment and very hot food (temperature).

NEUROLOGICAL PATHOLOGY

Peripheral vertigo

Balance is a complex function by which the human body constantly maintains a correct spatial orientation.

To this end, the human body has at its disposal:

- A system of acceleration sensors located in an area of the inner ear called the vestibular apparatus.
- Sensors that are responsible for the orientation of the body in relation to the ground, located in joints, muscles and tendons.
- The eyesight, which informs of the movements of the head and body in relation to the environment.

These three mechanisms send their information to the cerebellum and brain stem, and they quickly issue the right commands to compensate for changes in balance. These commands target the muscles that maintain body posture and eye position.

When there is a disturbance in the described mechanisms, unrealistic sensations of movement appear, even though neither the patient nor their surroundings move.

Vertigo is defined as a loss of spatial orientation, an erroneous and subjective sensation of displacement of objects in relation to the subject and vice versa. It must be distinguished from dizziness due to anxiety or instability, and from syncope.

Vertigo can be central or peripheral.

Central vertigo may be due to a migraine with brainstem aura (basilar migraine), vertebrobasilar insufficiency (ischaemia), tumours of the cerebellopontine angle, multiple sclerosis, etc.

Peripheral vertigo may be due to motion sickness, upper respiratory tract infections (otitis, labyrinthitis), positional vertigo caused by the adoption of a certain movement or posture of the head. Motion sickness occurs when there is an imbalance between the vestibular system stimulation and the visual stimulation. Sometimes, a hyperstimulation of the vestibular apparatus is accompanied by a certain visual stability, as occurs in tortuous journeys by car, on Ferris wheels, etc. On other occasions, the imbalance is inverse, with a supply of constantly changing visual axes and stability of the vestibular apparatus. This loss of stable visual references is the origin of height vertigo.

The most frequent vertigo in the mountains is the peripheral one; its onset is sudden, with a sensation of clear rotation and important vegetative symptoms (nausea, vomiting, pallor, cold sweating, diarrhoea, etc.).

Exploration

Nystagmus is the objective sign of vertiginous episodes. It is an involuntary and repeated movement of the eyeball that can be horizontal, vertical or rotating and consists of a slow and a fast phase of rectification towards the central line of the eye. In peripheral vertigo there is horizontal unidirectional nystagmus. It is triggered by the Dix-Hallspike manoeuvre (OR + 7.6).[375]

Another exploration that may be helpful is the Romberg test. To do this, the patient is placed in an upright position, with the feet together and the eyes closed. In peripheral vertigo, the patient has a tendency to fall to the slow phase side of the nystagmus.

Symptomatic treatment

- Antihistamines (diphenhydramine 25-50 mg every 6-8 hours) **(A)**.
- If nausea is present: ondansetron 4-8 mg.
- If there is anxiety: diazepam 5 mg.

Epilepsy

Epilepsy is a symptom that can be due to different causes: genetic, traumatic, infectious, malignant or pharmacological and toxic.

Seizures may be partial or generalised. They can be triggered by hyperventilation.

Partial seizures may begin with motor, sensory, autonomic or psychic symptoms. There is usually no disturbance of consciousness, although it may occur in the case of a complex partial seizure (temporal lobe). Sometimes they are generalised (*grand mal*).

Generalised seizures can be absences (petit mal) or generalised tonic-clonic seizures (*grand mal*). Absences are of rapid onset, with a brief period of unconsciousness (approximately 10 seconds) and rapid recovery. There may be increased or decreased muscle tone and clonic movements.

In generalised tonic-clonic seizures, there is a loss of consciousness, an increase in muscle tone of 1-2 minutes followed by the clonic phase, with generalised rhythmic jerking of the extremities lasting about 5 minutes. There may be sphincter incontinence, tongue bite, hot skin, sweating, and stertorous breathing. The patient is comatose after the seizure and recovers slowly (1-2 hours).

Treatment at the time of crisis

- Try to prevent the patient from hurting themself during falls, seizures, and clenching of teeth (tongue bite). In the comatose phase, try to avoid breathing difficulties by placing them in the recovery position.
- Secure a patent's airway by cleaning the mouth and placing a Guedel cannula.
- If a new seizure appears and a recurrence is suspected, diazepam 0.1-0.35 mg/kg may be given as a slow intravenous injection or 5-10 mg rectally. If the crisis continues, a repeat dose may be administered after 5-10 minutes **(C)**.
- Transfer to hospital.

Syncope

Syncope, or fainting, is a sudden, transient loss of consciousness that recovers spontaneously. It may be preceded by paleness, sweating, nausea, weakness, general ill feeling, or blurred vision.

The cause may be circulatory-neurological or cardiac.

Circulatory-neurological syncope is due to a sudden drop in blood pressure:

- Vasovagal syncope or lipotimia: is the most common, especially in young people. It usually appears in stressful situations (anxiety, fear, intense pain, heat, prolonged standing, or blood extraction). There's usually hypotension and bradycardia. Lower the patient quickly into the supine position.
- Orthostatic hypotension: appears when moving from decubitus to standing. Dehydration should be first ruled out.
- Reflex syncope: triggered by urination, defecation, coughing, or swallowing.
- Other causes: cerebral vascular accident (tingling, paralysis, speech disturbances, visual disturbances).

Syncope due to cardiological causes is the result of a reduction in cardiac ejection volume. The main causes are arrhythmias, obstructions and underlying heart disease.

Differential diagnosis

Hypoglycaemic syncope: loss of consciousness is not usually related to standing, it is accompanied by tachycardia. The onset of syncope is not sudden and is preceded by weakness, sweating and a feeling of intense hunger. The symptomatology subsides with the administration of glucose

Psychogenic syncope: hyperventilation can occur during a distress crisis with subsequent hypocapnia, which, rarely, can lead to a total loss of consciousness and is sometimes accompanied by paraesthesia of the extremities, sweating and palpitations, a feeling of thoracic oppression and dyspnoea that does not improve with decubitus.

Treatment (C)

Regardless of the type of syncope, it is necessary to:

- Place the patient in the supine position.
- There is no evidence that the elevation of the legs of the victim can promote the return of blood from the extremities to the vital organs (brain, heart, etc.).
- Loosen clothing (shirt collar, belt).
- Check constants (pulse, blood pressure, respiratory rate).
- If the patient does not regain consciousness, place a Guedel cannula, check the airways and infuse a perfusion of a saline solution if there is hypotension, and of glycoside solution if there is no hypotension.
- If consciousness is regained, move them into a sitting position and then slowly lift the patient up. If the person is unable to get up after 30 minutes in a recumbent or sitting position due to the recurrence of symptoms, refer them to a hospital.

Coma

Coma is a loss of consciousness. The patient's eyes are closed and they are unable to communicate with the outside world or obey simple commands.

Other degrees of decreased consciousness are confusion and stupor.

In confusion, the patient's eyes are open, they may obey an order, but there is a lack of attention, memory and orientation.

In clouding and stupor, the patient is very sleepy and must be stimulated to make external contact, otherwise consciousness decreases again.

The Glasgow or AVDN scales are useful for objectively assessing the level of consciousness and facilitating control of its development.

The causes of coma can be structural (haemorrhage or cerebral infarction, etc.) or metabolic (hypothermia, hypoxia, hyperglycaemia, hypoxia, toxic, medications, etc.).

Treatment

Ensure vital functions and transfer to hospital.

Cephalea

Most common causes in mountains

- Mountain sickness.
- Tension or muscle contracture headache.
- Vascular headache (migraine, cluster headache, etc.).
- Organic headache, due to:
  - Ocular otorhinolaryngological, maxillofacial, cervical pathology.
  - Cranial neuralgia (trigeminal, glossopharyngeal, post herpetic).
  - Subarachnoid haemorrhage.

Assessment demands a complete medical history and examination to identify severe cephalea.

Signs of alarm

- Headache of recent onset and sudden onset.
- Very intense headache.
- Progressive aggravation.
- Headache that impedes to sleep.
- Precipitated by physical exertion, coughing, or change of posture.
- Alarm accompanying symptoms:
  - Sleepiness, confusion, memory loss.
  - Malaise, myalgia, arthralgia.
  - Fever.
  - Neurological focus: weakness, loss of balance, etc.
  - Signs of meningeal involvement: rotation of the head when shaking it in the horizontal plane with a frequency of 2 or 3 times per second, is positive if the cephalea is exacerbated (it is the most useful sign); neck stiffness, signs of Kernig and Brudzinsky.[376]
  - Progressive visual disturbances.

Treatment (A)

- Rest in a quiet, dimly lit room with damp compresses on the painful areas.
- Tension headache: acetylsalicylic acid 1 g, paracetamol 1 g, ibuprofen 600-1,200 mg.
- Migraine:
  - Analgesics: acetylsalicylic acid 1 g, paracetamol 1 g, ibuprofen 600-1,200 mg.

Table 27.8. Differential diagnosis of cephaleae

Clinical history	Tension headache	Migraine	Organic headache
Age of onset	25-30 years.	<30 years old.	Any age.
Frequency	Daily.	1 year, 2-3/week	Daily.
Duration	Constant.	4-72 hours.	Mornings.
Localisation	Occipitocervical. The whole skull. Frontal bilateral.	Hemicranial.	Frontal. Localised.
Quality	Oppression. Tightness.	Pulsating.	Severe. Pulsating.
Associated symptoms	Dizziness.	Aura. Nausea and vomiting. Photophonophobia.	Focality. Epilepsy. Double vision.
Aggravating factors	Cervical mobilisation.	Cough, exercise. Valsalva manoeuvre. Postural changes.	Cough. Valsalva manoeuvre.
Triggers	Depression. Anxiety.	Stress. Food. Drugs.	Raised intracranial pressure.

  - Antiemetics: ondansetron 4-8 mg.
  - If the above are not effective: sumatriptan 50-100 mg oral, zolmitriptan 2.5 mg, rizatriptan 10 mg. Repeat the dose after 2 hours.
- In case of moderate-severe migraine crisis:
  - Sumatriptan 50-100 mg oral or 20 mg nasal or 6 mg subcutaneously.
  - Intramuscular analgesics: diclofenac 75 mg.

Anxiety

Is an unpleasant affective state of excessive tension, apprehension and worry. It can be accompanied by headache, tremor, choking sensation, tachycardia, dizziness, sweating, nausea, diarrhoea, tingling, etc.

Treatment (B)

Reassure the patient; in case of an acute situation you can administer diazepam 5-10 mg given orally or via the sublingual route.

Hyperventilation syndrome

Sometimes, anxiety is accompanied by thoracic oppression with the feeling of not being able to completely fill the lungs with air and a feeling of impending death. The patient responds with deep breaths and sighs to the point of producing respiratory alkalosis that causes a feeling of fading, tingling and tetany with spasm of the wrist or foot.

Treatment

Reassure the patient and make them breathe into an airtight bag (plastic glove, plastic bag) adapted to the mouth, where the exhaled carbon dioxide (CO_2) will accumulate. Breathe in fresh air every 6 seconds and replaced the bag until the tetany and hyperventilation improve. This turns the exhaled carbon dioxide in the bag into the appropriate level of blood carbon dioxide as it is rebreathed.

URINARY PATHOLOGY

Urinary tract infection

Frequent in women.

Signs and symptoms

Dysuria, frequent urination.

If there is back pain or chills, suspect a kidney infection (pyelonephritis).

Prevention

Drink plenty and urinate often.

Treatment (A)

Antibiotics (fosfomycin 3 g once, or every 2-3 days for 3 doses).

Renal colic

Pain from microlithiasis, crystals or stones in the kidney or urinary tract.

Signs and symptoms

Colicky lumbar pain radiating to the genitals with agitation, pollakiuria and sometimes vomiting. Lumbar punch is painful (OR + 27.7. OR – 0.9). There may be blood in the urine (OR + 73.1. OR – 0.3)[256].

Treatment (A)

- Diclofenac sodium type analgesics 75 mg IM, followed by oral or rectal diclofenac 50 mg every 6-8 hours until the pain subsides.
- Antiemetics (ondansetron 4-8 mg).
- Hot water baths, localised heat.
- Abundant oral hydration is controversial. Some authors think it is useful in accelerating the passage of calculus through the urinary tract, while others think it increases hydrostatic pressure, exacerbating colicky pain. There is agreement on treating dehydration if it exists.

SKIN INFECTIONS

Athlete's foot

Is a fungal infection of the skin in the interdigital spaces.

Prevention

Wash your feet thoroughly and then dry the interdigital spaces thoroughly.

Treatment (A)

Application of an antifungal ointment (terbinafine) every 12 hours.

Folliculitis, boils and abscesses

Localised skin infections, usually in the roots of the hair. If they are large they can cause abscesses.

Treatment (C)

- Topical hygiene.
- Local antibiotics (mupirocin, fusidic acid).
- Wet heat.
- Drainage and systemic antibiotic treatment may be necessary.

Cellulitis

Cellulitis is a bacterial infection of the skin and surrounding tissues. Microorganisms tend to spread easily to other areas.

Signs and symptoms

The site of infection is red, warm and tender to the touch, the boundaries are poorly defined, and fever is usually present.

Treatment (A)

- Antibiotics (amoxicillin with clavulanic acid 500/125 mg every 8 hours or, in case of allergy, clindamycin 300 mg every 8 hours.
- Rest with the leg elevated.

ACUTE LOW BACK PAIN

Is the sudden onset of lumbar pain, almost always in relation to unusual physical exertion; it usually worsens with movement of the area and occasionally radiates to the buttocks.

The **causes** are multiple: congenital anomalies of the lumbar spine, trauma, overexertion, degenerative anomalies (e.g. herniated discs), etc.

Treatment (A)

- Relative rest for the duration of the pain, which improves in recumbence with flexed knees.
- Localised heat.
- Analgesia (paracetamol or acetylsalicylic acid 0.5-1 g every 6-8 hours or ibuprofen 400-600 mg every 6-8 hours).

ANAPHYLAXIS

Is a severe allergic reaction due to various causes (wasp sting, snake bite, etc.).

Diagnosis

Anaphylaxis is most likely when one of the following three criteria is met:

- Acute onset (minutes or hours) of a syndrome affecting the skin and/or mucous membranes (hives, erythema, flushing, oedema) along with at least one of the following:
  - Respiratory involvement (dyspnoea, wheezing, stridor, a decreased maximum expiratory flow, hypoxemia).
  - Decreased blood pressure or symptoms associated with organ dysfunction (hypotonia, syncope, incontinence).
- Rapid onset (minutes or hours) of two or more of the following symptoms after exposure to a potential allergen for that patient:
  - Skin and/or mucous membrane involvement (absent in 10-20% of patients).
  - Respiratory compromise.
  - Decreased blood pressure or associated symptoms of organ dysfunction.
  - Persistent gastrointestinal symptoms (nausea, vomiting, diarrhoea, abdominal pain).
- Decreased blood pressure within minutes to several hours after exposure to an allergen known to that patient:
  - Infants and children: low blood pressure or systolic BP drop >30%.
  - Adults: systolic BP <90 mmHg or >30% drop over basal.

Prevention

Consult an allergist about the possibility of performing a desensitisation treatment and/or the convenience of pre-filled adrenaline syringes.

Treatment

- Patient approach using the A-B-C-D-E method.
- Adrenaline 1/1000 (1 mg/mL): 0.3-0.5 mL IM which can be repeated every 5-15 minutes up to a maximum of 3 doses if necessary. In severe reactions, 1/10,000 (0.1 mg/mL) adrenaline may be used: 1 mL IV in 5 minutes, followed by a perfusion of 1-4 μ/min. If no venous route is available, it can be administered by the endotracheal route tat a dose of 1/10,000: 5 mL or 1/1,000: 0.5 mL **(A)**.
- In case of angioedema, severe aphasia, tongue and oropharyngeal oedema, consider that the risk of respiratory involvement is high and assess the need for an early intubation, since if it is delayed, the patient may deteriorate in 0.5-3 hours, presenting with severe aphasia, laryngeal oedema, massive swelling of the tongue, face and neck and hypoxemia. At this point, orotracheal intubation and cricothyroidectomy may be impossible to perform.
- Oxygen to maintain SpO_2 between 94 and 98%.
- Physiological saline solution. If hypotension is present, initially administer 20 mL/kg in children or 1-2 (or even 4-8) litres in adults.
- Inhaled salbutamol if there is bronchospasm.
- Antihistamines: diphenhydramine 25-50 mg every 6 hours in 3-5 minutes OV, IM or IV **(A)**.
- H2 blockers: ranitidine 50 mg VO, IM or IV
- Corticosteroids: methylprednisolone 1-3 mg/kg every 6 hours IV for 24-48 hours. Benefits are seen at 4-6 hours. Hydrocortisone at dose of 250-1000 mg may be used **(C)**.
- Urgent transfer to hospital.
- In case of insect stings, remove the stinger using the blade of a knife to avoid squeezing it, as more venom could be introduced. Apply localised cold to the lesion.

RECOMMENDATIONS FOR THE MANAGEMENT OF PRE-EXISTING ILLNESSES OR CONDITIONS IN MOUNTAIN ACTIVITIES

General recommendations

Before traveling to do the activity:

- Talk to your doctor at least 6 months before travelling. Be informed about the additional

risks that the trip may pose to your illness (e.g. altitude or activity).
- Planning for treatment. Find out what medical services are available at your destination.
- Make a list of contacts at your place of residence and destination.
- Inform your group of your medical condition, symptoms and treatment. Your illness may affect all members of your group.
- Make sure the whole group knows how to administer first aid.
- Prepare a first aid kit with your medications. Include a list with clear instructions for use
- Consider carrying a surplus to divide the kits among several people.
- Ask your doctor for a letter explaining your illness, the treatment and possible contact details (translate if necessary).
- Before getting vaccinated, inform the nurse of your medical condition.
- Take out travel insurance to cover your illness and the additional risks of your trip. It can be difficult, expensive and sometimes impossible to insure all medical conditions.

During the activity (or at altitude):
- Always have your medical information at hand.
- Each day, write down any medications taken and any changes in your condition.
- If your symptoms worsen, do not continue the activity or ascend, descend if necessary.
- Be honest with your peers about changes in your medical condition.
- Take care of family, friends and fellow travellers.

Diabetes

Before travelling or doing activities:
- Before booking your trip or joining the mountain activity, have an ophthalmological check-up. If retinopathy is present, avoid activities at high altitudes.
- If there are circulatory or neurological problems, consult your doctor.
- Establish good blood glucose control during the months prior to travel.
- Purchase a good (and a replacement) glucometer that works at low temperatures and altitudes.
- Plan your diet.
- Carry plenty of insulin to cover changes in requirements.
- Practice managing your diabetes during activity and in adverse conditions.
- Contact groups of diabetics who carry out similar activities.

At height or during the activity:
- Always carry emergency glucose, glucometer and medication at hand.
- Do not allow insulin to freeze. Carry it in a pocket near the body.
- Avoid infections. If you get sick, get help. Do not stop taking insulin.
- Remember that exercise decreases the need for insulin and rest increases it.

Arterial hypertension. Ischemic heart disease

At high altitude, episodes of hypertension may occur and stabilise in 1-2 weeks. In general, you do not need to change your high blood pressure medication or increase your dosage.

Altitude, cold, and exertion can trigger angina pectoris in patients with ischemic heart disease.

Before travelling or carrying out activities:
- Have your heart checked and seek advice on emergency medications for angina pectoris.
- Ensure acceptable and stable blood pressure before travelling or starting mountain activities.
- Maintain proper physical fitness.
- Learn about possible problems that stress medications can cause with exercise, altitude and cold.
- It is advisable to have had a negative stress test in the last year.

At high altitude or during the activity:
- Reduce dietary salt intake.
- Take your usual medication.
- Protect yourself from the cold.
- Extend height acclimatisation for a couple of days and reduce the intensity of exercise during the first few days.
- If you feel unwell, stop the activity or do not ascend further and consider descending, communicating it to your teammates.

Allergies / anaphylaxis

A person who has had an allergic reaction may have it again within 24 hours. Get medical attention as soon as possible.

Before travelling or engaging in activities:

- Include adrenaline, antihistamines, and corticosteroids in the first-aid kit.

At heights or during the activity:

- Wear a bracelet detailing allergies.
- Carry self-injectable adrenaline and be prepared to use it.

Respiratory problems. Asthma

Asthma can get worse with altitude, cold, and exercise. But there are asthmatics who get better due to the natural increase in endogenous corticosteroids and the lower amount of allergens in the air.

Before travelling or doing activities:

- Any breathing problem at sea level can seriously affect your performance at altitude and during a mountain activity.
- Confirm that you are being vaccinated correctly. Consider flu vaccination.
- Train to achieve a suitable physical form, starting at low altitude and with low intensity and volume exercises.
- In case of asthma: asthma should be stable. Identify what triggers asthma attacks and avoid these stimuli during activity or high altitude travel. Include spare inhalers and corticosteroids in your first-aid kit.

At height or during the activity:

- Ascend slowly.
- Avoid problems by reducing activity, taking medication, and descending if necessary.
- In case of asthma: carry inhalers at all times and avoid anti-inflammatory drugs (aspirin, ibuprofen).

Epilepsy

Before travelling or doing activities:

- The epilepsy must be stable, no seizures in the six months prior to travel.
- Be informed about restrictions on risky activities and inform your peers of your condition.
- Confirm that anti-malarial drugs do not interfere with the antiepileptic medication.

At height or during the activity:

- Know the diseases that can affect your medication.
- Identify and avoid factors that may trigger a seizure (e.g. alcohol, fatigue).
- Antiepileptic drugs can affect sleep and coordination. These symptoms can also be caused by altitude sickness. If in doubt, descend.
- A seizure in an exposed location can be life threatening. Drowsiness may occur after a seizure and rest is needed.

Migraine

Decreased oxygen partial pressure at altitude increases the risk of a migraine crisis in people who suffer from it. It can be difficult to distinguish from acute mountain sickness (AMS) –in mountain sickness, the headache does not have an aura, nor is it unilateral–. If taking the usual anti-migraine medication does not help, it should be considered that it is AMS.

Cerebrovascular accident (CVA)

There is no evidence that altitude increases the incidence of stroke in tourists, but it has done so in soldiers in the Himalayas.

Symptoms of CVA have been observed in young people (limb weakness on one side of the body, blindness, speech difficulty) that resolve with oxygen and descent to lower altitudes.

If symptoms of CVA appear, consult a doctor urgently.

If you have had previous CVAs and decide to do the activity, continue to take your medication and limit activity at high altitude.

People taking anti-aggregants (aspirin, clopidogrel) should be careful to avoid trauma due to the increased risk of bleeding produced by these medications.

A history of eye surgery

Uniform corneal oedema may occur in response to low oxygen partial pressure. In people who have had corneal surgery (e.g.

corrective vision surgery), irregular, potentially severe oedema may occur. Laser surgery produces a smaller and less irregular oedema. Retinal bleeding in the back of the eye is common and may cause dark spots in vision that resolve on their own.

Pregnancy

During pregnancy, there are high hormone levels, such as progesterone, which increase the respiratory rate and oxygen saturation and can protect against AMS.

Many pregnant tourists visit high-altitude destinations such as Colorado each year and no complications have been reported.

Women with complications in pregnancy, such as hypertension, preeclampsia, placental insufficiency, or any other complication, should avoid unnecessary exposure to high altitudes. Pregnant women can take acetazolamide, but only if it is really essential; a slow ascent is preferable to taking medications.

As long as there is no risk of pregnancy, sleeping at altitudes between 2,800 and 3,000 m is safe for the foetus. There is not enough information to provide advice at higher altitudes.

Recommendations

- Have a gynaecologic check-up to make sure it is a low-risk pregnancy.
- If you are skiing, cycling, climbing, be cautious regarding trauma.
- Avoid excessive exercise.
- Stay well hydrated.
- Avoid altitude sickness.
- Seek medical attention early if there is a problem.

28 CLINICAL TECHNIQUES

Some of the techniques described are usually practised in health facilities but, on some occasions, they have helped to save the lives of injured mountaineers. Because they are invasive and can cause serious complications, they should only be practiced by medical personnel who are expert and trained in their implementation and in situations where, after having assessed the risk/benefit ratio, it is concluded that there is absolutely no other choice but to do so. This training is available at health facilities.

The equipment needed to practice most of these techniques is in helicopters and medicalised ambulances, in most ski and mountain resorts, and sometimes in the physician's mountain rescue backpack.

OROTRACHEAL INTUBATION

Is a technique that must be performed by the doctor, but that the rest of the medical personnel and rescuers must know in order to help.[205]

Orotracheal intubation may be difficult (>15% of intubations failed)[203] and potentially dangerous, and therefore requires experience and continued training (125 initial learning intubations and two every 6 months to maintain the ability) **(A)**[214]. If three attempts fail to achieve orotracheal intubation, an alternative method should be used **(A)**. During the manoeuvre, the cervical spine is usually hyperflexed to C5-C6 level and hyperextended to C1-C2 level (first and second most common places of complete cervical fracture in trauma patients).

Indications[377]

- Airway obstruction.
- Hypoventilation.
- Severe hypoxemia not corrected by oxygen administration.
- Decreased level of consciousness (GCS <9).
- Cardiorespiratory arrest.
- Severe haemorrhagic shock.
- In addition, if the patient suffers burns, also consider intubation if there is:
  - Over 40% of total body surface area with burns.
  - Moderate-severe facial burn.
  - Moderate-severe oropharyngeal burn.
  - Suspected thermal airway injury.

Complications

- Impossibility of intubation.
- Selective intubation of the bronchus or oesophagus.
- Provocation of vomiting with risk of bronchoaspiration.
- Trauma to the teeth or soft tissues.
- Others: jaw dislocation, cervical spine or airway injury, increased intracranial pressure, etc.

Material

- Laryngoscope with curved blades for adults and flat blades for small children.
- Tracheal tube: women 7-8.5 mm, men 8-10 mm; in case of emergency 7.5-8 mm is suitable for both men and women; children, diameter in mm = (16 + age)/4.
- Syringe to inflate the endotracheal tube balloon.

- Mouldable clamping guide to insert the tube.
- Suction system with probes of different sizes.
- Insufflation balloon.
- Oxygen.
- Intubating introducer (Frova).
- Oropharyngeal cannula.
- Bandages or tapes to fix the tube.
- Water-soluble lubricant.

Technique

- Check that all the material is in optimum condition (laryngoscope light, the integrity of the pneumatic tube ball, etc.).
- Patient in the supine position with cervical spine control performed by an assistant.
- Ventilation with a pharyngeal cannula and 100% O_2 insufflation balloon for 3-5 minutes.
- Insert the blade of the laryngoscope with the left hand through the right buccal corner, moving the tongue towards the opposite side, in order to visualise the vallecula where the tip of the blade will be placed. Pull the handle of the laryngoscope up and forward to view the vocal cords.
- The assistant keeps the cervical spine immobilised in a neutral position and pinches both sides of the cricoid cartilage (under the Adam's apple) with index and thumb. It presses it downward to occlude the upper end of the oesophagus, preventing air from entering the digestive tract and regurgitation of the gastric contents and improving the vision of the glottis during intubation (Sellick's manoeuvre). This manoeuvre is applied during anaesthetic induction and is maintained until ideal conditions for intubation have been achieved (2-3 minutes). There is little evidence to support the widespread belief that applying pressure to the cricoid reduces the incidence of aspiration during a rapid intubation sequence.
- With the right hand, insert the endotracheal tube with the locking guide into its interior for about 22 cm, without pressing on the teeth or oral tissues.
- Remove the locking guide and inflate the air balloon with approximately 10 cm3 of air. If the ambient air is cold, do not over-inflate the balloon because as it warms up, the air will expand and can burst the pneumo padding.
- Initiate ventilation by checking for correct tube placement by auscultation of both pulmonary and epigastric fields to rule out selective right bronchial intubation or oesophagal intubation.
- Fasten with tape.
- Once intubated, insufflate the patient with 100% oxygen.

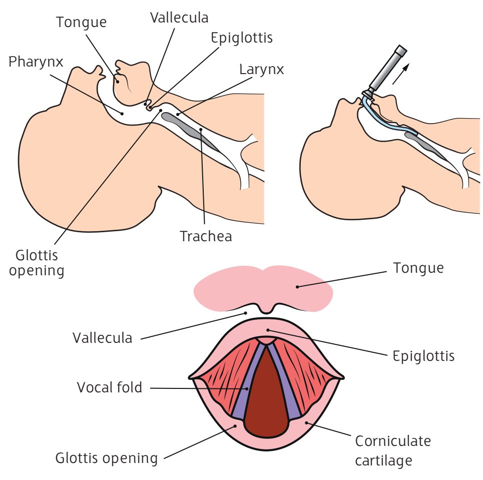

Figure 28.1. Orotracheal intubation.

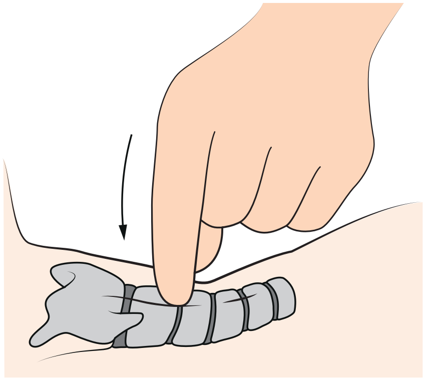

Figure 28.2. Sellick manoeuvre.

Intubation should not exceed 30-60 seconds to avoid hypoxia; if this is not achieved within this time, ventilate the patient with balloon and mask and 100% O_2 for 1-2 minutes and then try again.

In snow, it is difficult to see the airways because of the high brightness, so cover the rescuer with a jacket to darken the field of vision and better highlight the airways under the light of the laryngoscope.

Drugs used in orotracheal intubation

In orotracheal intubation (OTI) of a polytraumatised patient, the rapid-sequence anaesthetic technique is used with the following substances:

- Analgesic: fentanyl.
- Depolarizing muscle relaxants: succilcholine.
- Non-depolarizing muscle relaxant: rocuronium.
- Hypnotic: midazolam, etomidate.

Considerations

- The patient may have a full stomach.
- They may be hemodynamically unstable.
- There is a possibility of brain involvement and cervical spinal cord injury.

Method for rapid sequence induction in the OTI

Pre-oxygenation with a face mask and 100% O_2 for 3-5 minutes or 7 breaths at full lung capacity.

Pre-treatment

- Atropine 0.01 mg/kg, to counteract the cardiac depressant effect of anaesthetics.
- Fentanyl 1-2 µg/kg, which is analgesic and deepens anaesthesia.
- Lidocaine 1-1.5 mg/kg, if there is cranial involvement or HTN. It prevents the increase of intracranial pressure.

Administered 3-5 min before induction.

Initiate cricoid pressure (Sellick manoeuvre) to compress the oesophagus and prevent the gastric contents from flowing upward.

Induction

- Midazolam: 0.05-0.2 mg/kg. Sedation with midazolam is important in order not to increase intracranial pressure with the intubation manoeuvre and is not necessary in case of cardiorespiratory arrest.
- Succinylcholine: 1-1.5 mg/kg, in emergency intubation it is only used if absolutely necessary and the vocal cords are visualised with the laryngoscope, since if it is not certain it will be possible to intubate, we may find ourselves in the situation of having an accident without an open airway to which we have relaxed the musculature and therefore cannot breathe.
- Rocuronium: 0.6 mg/kg, used if ventilation is insufficient without relaxation.
- Fentanyl: 1-2 µg/kg.

As for the use of muscle relaxants during the intubation manoeuvre, there are some points that we must emphasise. Both succinylcholine and rocuronium are valid options. Succinylcholine has important adverse effects that contraindicate its use in many situations. Recently, an agent, sugammadex, has appeared that reverses the effects of rocuronium and vecuronium in less than 2 minutes, making them a very attractive option in the intubation manoeuvre. For these reasons, although both options may be effective, rocuronium probably offers a more appealing safety profile.

Maintenance

- Midazolam: 0.3-3.3 µg/kg/min.
- Fentanyl: 0.03-0.06 µg/kg/min or 1 µg/kg in bolus every 30 min.
- Rocuronium: 0.6 mg/kg in bolus every 30 min.

If the patient is hypotensive, use the lower ranges of hypnotics and morphine derivatives, both in induction and maintenance, as well as an adequate hydration. In this case, the use of etomidate (0.2-0.3 mg/kg) (not during maintenance) or ketamine (1-4 mg/kg) may be considered during intubation.

Table 28.1. Drugs used in intubation

Drug	Effects
Hypnotic: midazolam (Dormicum®), 3 mL vial containing 15 mg	• Central nervous system: anxiolytic (low doses), hypnotic (high doses), anticonvulsants, reduction of intracranial pressure. • Respiratory: dose-dependent respiratory depression (20% of cases). • Cardiovascular: decrease in blood pressure due to a decrease in the vascular resistance in hypovolemic patients. • Its hypnotic (non-hemodynamic) effects can be reversed with a flumazenil dose of 0.2 mg in 2 minutes up to a total of 3 mg.
Depolarising relaxant: succinylcholine (Anectine®), 2 mL vial containing 100 mg	• Substance capable of producing a rapid, short duration (3 min) muscle paralysis in 30 seconds. • Bradycardia primarily in patients taking digitalis. • Discreet increase in blood pressure. • Increased intraocular pressure. • Increased intragastric pressure and intestinal peristalsis. • Fasciculation. • Most of these effects can be mitigated with a small dose of a previous non-depolarising relaxant. • Can cause hyperkalaemia, increase ICP and produce malignant hyperthermia in predisposed patients.
Non-depolarising relaxant: rocuronium (Esmeron®), 5 mL vial containing 50 mg	• Quick acting (<2 min). • Sugammadex counteracts its effects in less than 2 minutes. • Slight hypotension. • Tachycardia.
Analgesic: fentanyl (Fentanest®), 3 mL vial containing 150 µg (0.15 mg).	• Central nervous system: reduces oxygen consumption and blood flow. • Respiratory: muscle stiffness of the thoracic wall. • Cardiovascular: bradycardia. • Fentanyl: 100 times more potent than morphine and of shorter duration.

LARYNGEAL MASK AIRWAY

As it does not exceed the glottis –as is the case with the Guedel cannula– the legislation of most European countries allows its placement by a non-medical health carer trained in its manipulation. If we add to this the fact that, if the Fastrach model is used, the doctor can easily intubate through it, its use could be highly recommended in out-of-hospital and mountain emergency departments.

It has the advantage of its quick and easy handling (B), allows for proper ventilation and can also be inserted blindly without aligning the axes or visualizing the glottis, which represents a clear advantage in polytraumatised patients, in which a cervical injury will always be suspected. It can be placed through a tooth hole as small as 20 mm. Its disadvantage is that it does not completely isolate the airway, as it is above the vocal cords and does not prevent bronchoaspiration. There is a more useful variant (Fastrach) that allows intubation through it without the need to remove it beforehand, thus avoiding this problem.

It is used in case of difficult intubation or by personnel with little training in orotracheal intubation. With the Fastrach laryngeal mask, 95% of patients are successfully intubated, a similar figure to that obtained with a fibre optic intubation.

Furthermore, the Fastrach laryngeal mask causes less extension in C1-2 and C2-3 areas than orotracheal intubation with a laryngoscope and does not increase the intracranial pressure (ICP).[379]

The mask is inserted deflated and, once in its final position, it is inflated through a catheter that exits to the outside.

There are several sizes:

- Small adults: nº 3, with a volume of 20 mL.
- Bigger adults: nº 4, with a volume of 30 mL.
- Large adults: nº 5, with a volume of 40 mL.

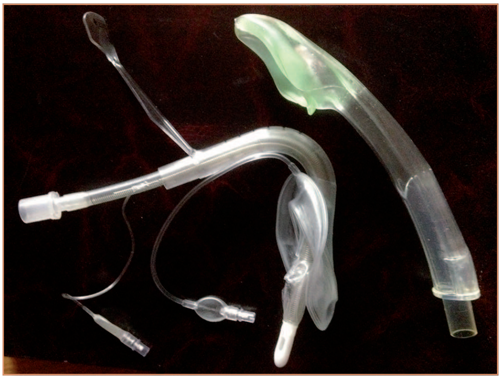

Figure 28.3. LMA Fastrach® type laryngeal mask with tube and i-gel® type mask.

I-GEL® SUPRAGLOTTIC AIRWAY

A type of laryngeal mask whose cuff is made of gelatinous material and does not require inflating. They incorporate a drainage tube that allows the passage of a gastric tube. It is inserted faster than the conventional laryngeal mask.[380]

LARYNGEAL TUBE (KING LT)

The laryngeal tube is an effective system of access to the airway, small and easy to insert, allows proper oxygenation and ventilation and prevents the gastric contents from entering the airway.[381]

According to the manufacturer's instructions, LT placement technique follows the following sequence:

- After pre-oxygenation, and once an adequate anaesthetic level is reached, the head is placed in hyperextension, in a position similar to that of endotracheal intubation. Although this is the ideal position, the LT can be placed in any position due to its shape.
- Prior to its introduction, the air of the endotracheal cuff must be emptied to avoid folds. Both balloons are then lubricated. The recommended technique is to grasp the tube in a feather-like manner over the black line area (teeth mark).
- With your free hand, open the mouth and make sure that the tongue does not fold backwards during the downward movement of the LT. Never force the manoeuvre. Press on the back of the LT, with the tip resting on the patient's hard palate at the midline, and gently slide it toward the hypopharynx until the middle black line is at the level of the dental arch. At that time, do not hold the mouth during the last part of the sliding movement to allow the tongue and epiglottis to slide down gently.

The balloons are insufflated and emptied by means of a special syringe for each size of LT, which is inserted into a connector that includes a unidirectional valve that prevents gas reflux after insufflation. To empty the balloons, move the valve with the tip of the syringe and aspirate the gas from the balloons. Due to its special design, the pharyngeal balloon is inflated first, thus stabilizing the tube; once it is adjusted to the patient's anatomy, the air passes to the other balloon and the oesophageal balloon is inflated, thus sealing the nasopharynx and oropharynx. With the two balloons puffed up, the airway of the digestive tract is isolated, so when the air is breathed in, it is directed through the ventilation opening towards the larynx, as it is the only open airway that offers less resistance and thus achieves pulmonary ventilation.

The LT is available in 5 sizes, with different coloured connectors, so that all sorts of individuals are covered.

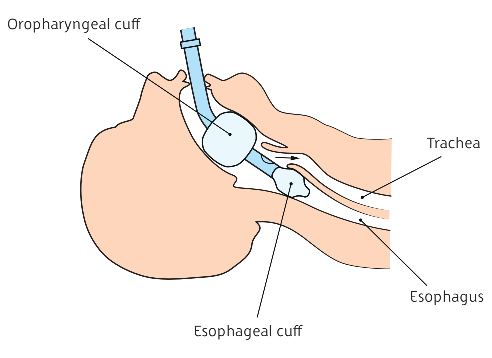

Figure 28.4. Laryngeal tube.

CRICOTHYROID PUNCTURE

Is a technique that must be performed by the doctor, but that the rest of the medical personnel and rescuers must know in order to help.

It is a procedure to perform subcutaneous transtracheal ventilation to save time to perform a definitive tracheotomy.

It is indicated in case of failure of intubation and contraindication for cricothyroidotomy.

Complications

- Tracheal, oesophageal or thyroid perforation.
- Bleeding, hematoma.
- Subcutaneous or mediastinal emphysema.
- Pneumothorax.
- Cellulitis.

Material

- Source of oxygen.
- Antiseptic.
- Tape for fixing or taping.
- 14G catheter in adults and 12G in young children.
- Adapter for fan valve with T-connector.

Technique

- Patient in supine position.
- Locate the puncture site between the lower relief of the thyroid cartilage and the upper relief of the cricoid.
- Clean with antiseptic.
- Stabilise the thyroid cartilage with the left hand.
- Connect the catheter to a 10 mL syringe with 2-3 mL of saline solution and puncture the midline in the direction of flow through the membrane joining the two cartilages.
- After the puncture, maintain negative pressure with the plunger of the syringe and direct the needle towards the flow area, towards the trachea, at an angle of 45º. After checking the air inlet to the syringe (bubbling), remove the needle and insert the entire catheter.
- Fix by keeping the angle at 45º to prevent the catheter from bending.
- Connect to 15 L/min oxygen source via T-connector.
- Perform high pressure ventilation with a 1:4 ratio, i.e. plug the T-tube opening for one second and unplug for 4 seconds to facilitate the passive exhalation.
- This palliative measure allows for minimal ventilation for about 10 minutes, while the transfer or other ventilation techniques are performed. In any case, it is not advisable to maintain this type of ventilation for more than 30-45 minutes.

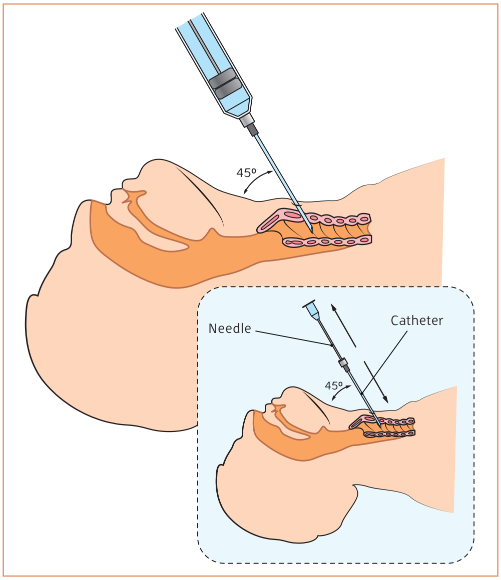

Figure 28.5. Cricoid puncture.

CRICOTHYROIDOTOMY

It is a technique that must be performed by the doctor, but that the rest of the medical personnel and rescuers must know to be able to help.

Indications

- Inability to perform endotracheal intubation.
- Severe maxillofacial trauma.

Contraindicated for children under 10-12 years of age.

Complications

- Hypoxia due to malposition of the cannula.
- Bleeding, hematoma, blood aspiration.
- Dysphonia, vocal cord paralysis.

- Glottic or subglottic stenosis.
- Perforation of the trachea or oesophagus.
- Pneumomediastinum.
- Cellulitis.

Material

- Source of oxygen.
- Antiseptic.
- Sterile gloves.
- Local anaesthesia.
- 10 mL syringe with intradermal needle.
- Sterile gauze.
- Fixing tape.
- 10-11 scalpel blades with handle.
- Scissors.
- Haemostatic tweezers.
- 5-6 mm tracheostomy tubes or 5-6 mm tracheal tubes.

Technique[382]

- Place the patient in the supine position.
- Locate the puncture site between the lower relief of the thyroid cartilage and the upper relief of the cricoid.
- Clean with antiseptic.
- Stabilise the thyroid cartilage with the left hand.
- Make a longitudinal incision over the skin, followed by a transverse incision through the cricothyroid membrane.
- Insert the handle of the scalpel and turn it 90º.

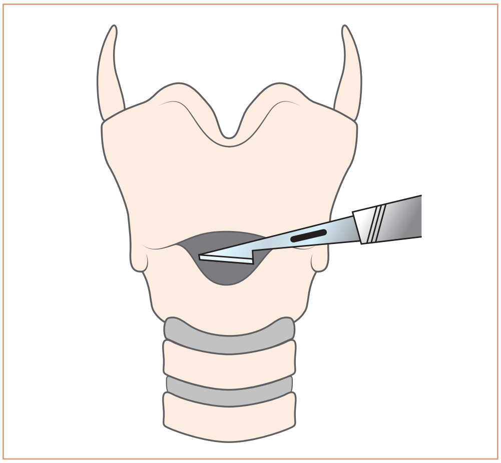

Figure 28.6. Cricothyroidotomy.

- Insert the tracheostomy tube in the caudal direction towards the trachea.
- Inflate the cannula balloon and breathe in air to check the expansion of the lungs.
- Attach the cannula with gauze dressing and tape.

There are commercially available sets for performing cricothyroidotomy by direct percutaneous puncture.

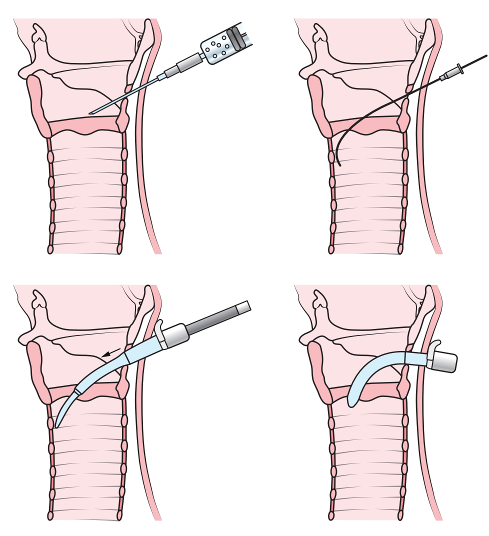

Figure 28.7. Cricothyroidotomy.

CANNULATION OF A PERIPHERAL VENOUS LINE

It is a technique that must be performed by medical personnel, but that the rescuers must know in order to help.

In patients with cardiac arrest or circulatory collapse, the veins of the antecubital fossa are used. In stable patients, it is preferable to choose the distal veins of the forearm.

Technique

- Apply a tourniquet above the puncture site.
- Locate the vein and clean the area with antiseptic.
- Press with your finger on the distal area of the vein to hold it still.
- Puncture the skin, with the head joint of the needle facing upwards, 0.5 cm from the

vein, and penetrate into its interior through its upper wall.

- After checking the blood flow, advance the catheter while keeping the needle fixed.
- Remove the tourniquet.
- Remove the needle from the angiocatheter and connect the perfusion system after purging to remove air.
- Clean the puncture site with anaesthetic and cover with a sterile dressing.

Size of the canula

- Children: 20 G.
- Women: 16 G.
- Men: 14 G.

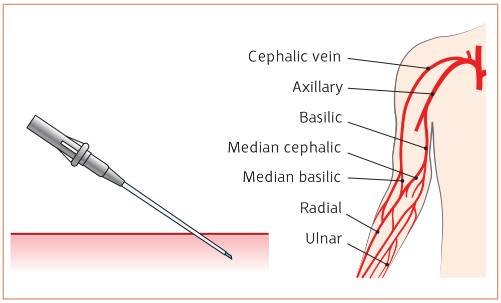

Figure 28.8. Intravenous route.

INTRAOSSEOUS INFUSION

Used in case of failure to catheterise a peripheral venous line in 90 seconds or after three attempts.

The liquids flow into the general circulation with a similar speed to that of a peripheral pathway.

It is contraindicated in case of a complete fracture of the limb or a severe abdominal trauma.

Material required

- Intraosseous puncture needles.
- 5, 10, 20 mL syringes and conventional needles.
- Local anaesthetic.
- Antiseptic solution.
- Sterile gloves.
- Physiological saline solution.
- Perfusion system.
- Three-way tap.
- Gauze.
- Kocher clamp.
- Bandages.
- Surgical tape.

Puncture site: in the adult the accessible points are the iliac crest, the sternum and the distal tibia.

Technique

Whenever possible, sterile techniques should be used with prior hand washing.

In the case of choosing the distal tibia for intraosseous puncture, the following procedure is used:

- Identification of the puncture site: the internal malleolus of the tibia is felt and punctured 1-2 cm above and behind the saphenous vein.
- Hand washing and gloving.
- Clean the skin with an antiseptic solution.
- Check the needle and ensure proper alignment of the outer needle bevels and the inner stylet.
- Local anaesthesia if the patient is conscious.
- The intraosseous needle is held with the dominant hand in such a way that the grip is placed on the inner heel of the dominant hand and the index finger and thumb holds it approximately 1 cm from the tip. The puncture site is felt with the other hand.
- The needle is placed perpendicularly at this point. The needle is inserted with a firm, rotating motion if necessary, until the periosteal resistance decreases, indicating that it has reached the medullary canal.

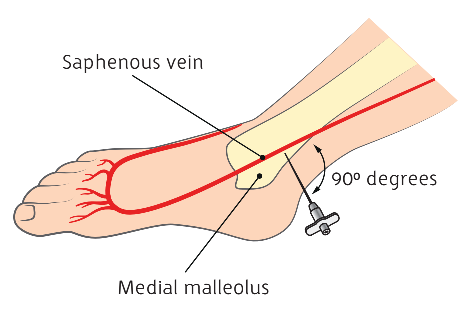

Figure 28.9. intraosseous puncture.

- Unscrew the lock and remove the stylet from the needle.
- Stabilise the intraosseous needle and slowly inject 10 ml of saline solution, checking the permeability of the pathway and the non-extravasation of the fluid infused.
- If the injection test is satisfactory, disconnect the syringe, evacuate the air from the IV and connect the fluid therapy system, fixing it to the surrounding skin with two Kocher clamps wrapped in bandages, respecting the device.

THORACENTESIS AND THORACIC DRAINAGE

Indications

Pneumothorax and tension hemothorax.

Complications

- Cellulitis.
- Empyema.
- Hematoma.
- Pneumothorax.

Material

- Antiseptic.
- Sterile gauze and surgical drapes.
- Sterile gloves.
- Local anaesthesia.
- 14-16 G catheter or Pleurocath®.
- 10 mL syringe.
- Saline solution.
- Surgical tape.

Technique

Normally, two puncture points are used:

- The second intercostal space in the middle clavicle line is usually used when the clinical indication is clear and radiology is available to confirm the position of the tube. In an emergency situation it is more dangerous due to the increased possibility of hemothorax and possible injury to the mammary artery, so there is controversy as to whether this is the point of choice. Placement in the middle third of the collarbone minimises the risk of injury to the internal mammary artery during the emergency procedure. If the needle is placed too medially with the breastbone, it can cause a hemothorax by injuring the lower set of intercostal vessels or the internal mammary artery.[383, 384]
- The fourth or fifth intercostal space in the anterior axillary line is considered less dangerous.

Pneumothorax drainage technique with an angiocatheter

- Clinically confirm tension pneumothorax.
- Locate the puncture site: fourth or fifth intercostal space in the anterior axillary line or second intercostal space in the midclavicular line (where the second rib attaches to the Angle of Louis in the breastbone). 60% of emergency physicians were unable to identify the second intercostal space.[385]
- Clean the puncture site with antiseptic and isolate with sterile drapes.
- Anaesthetise the puncture site and the periosteum of the rib and the parietal pleura, which, when crossed, allows us to confirm the presence of pneumothorax because air is easily aspirated.
- Connect the catheter to a 10 mL syringe with 2-3 mL of saline solution.
- Insert the catheter perpendicularly to the skin, just over the upper edge of the 3rd rib (the vessels are larger at the lower edge of the rib) in the case of puncturing the second space, applying negative pressure with the plunger of the syringe to feel the bubbling that is felt when piercing the pleura. The average wall thickness of an adult is 5.36 cm, so an 8 cm catheter could reach the pleural space in 99% of cases, while a 5 cm catheter would only reach it in 75% of cases.[386, 387]
- Remove the needle with the syringe and leave the catheter.
- Attach the catheter and apply a dressing to the puncture site.
- Connect the system to a Heimlich valve or improvise a valve with the finger of a glove that is made with a small incision in its upper part and then attached to the needle.
- Another system, while preparing the chest tube and Pleurevac®, is to connect the cath-

eter to a syringe without the plunger and fill it with saline solution.

Insertion of the Pleurocath®

- Place the patient in the supine position and locate the middle axillary line between the 5th and 6th intercostal space. Perform cleaning and antisepsis of the skin.
- The thin tubes have an external introducer needle. To facilitate the progression of this procedure, it is convenient to make a small incision in the skin with a scalpel blade and then the tubes only have to be pushed through the previously anaesthetised area until they reach the pleural chamber. The bevel of the needle should face towards the pulmonary apex.
- Once the pleural chamber is reached, the tip of the needle is directed to the apex and the catheter is inserted until the tip is considered to be correctly located.
- Fix it in the tube with a stitch and dressings and connect it to the vacuum system via the three-way tap.

THORACIC TUBE

This is a technique that can cause serious complications and should only be performed if the injured person is dying as a result of a respiratory failure secondary to pneumothorax, hemothorax or hemopneumothorax, if the necessary material is available and if the person performing the technique is properly trained in its performance. The new Seldinger insertion technique type chest drain is very useful as it is safer for less experienced professionals.

Indications

Drainage from a pneumothorax, hemothorax or hemopneumothorax.

Complications

- Injury to internal organs.
- Bleeding from injury to the intercostal vessels or internal mammary artery.
- Injury to the intercostal nerve with posterior neuralgia.
- Empyema.
- Pulmonary oedema from sudden re-expansion of the pneumothorax.
- Subcutaneous emphysema.
- Poor tube position.

Material

- Antiseptic.
- Sterile gauze and sizes.
- Sterile gloves, cap, mask and gown.
- Local anaesthesia.
- Thoracic tube 20-28 Fr, because, in case of trauma, in addition to draining the air it must drain the blood.
- Water seal (Pleurevac®) or Heimlich valve.
- Nº 10 scalpel blades with handle.
- Haemostatic Forceps.
- Mayo scissors.
- 2/0 suture silk.
- Surgical tape.

Technique

- If spinal cord injury has been ruled out, place the patient, if possible, in a seated position with arms forward. If the patient is unable to sit, the head and chest should be higher than the rest of the body, and the side of the body on which the tube will be placed should be in the upper position. The hand is placed on the side where the drain will be inserted, above the head.
- Ensure adequate oxygenation and ventilation.
- Locate the insertion site: 5th intercostal space, anterior axillary line.
- Anaesthetise the incision area and the periosteum of the rib and the parietal pleura, which when crossed allows us to confirm the presence of pneumothorax because air is easily aspirated.
- Make a horizontal incision in the skin, parallel to the rib, 2-5 cm in the location determined, slightly below the upper rim of the rib, to create an ascending tunnel that prevents the reproduction of the pneumothorax when the tube is removed.
- Perform blunt dissection of the subcutaneous tissue and intercostal muscle with forceps.

- Puncture the parietal pleura with the tip of a haemostatic forceps, just above the upper edge of the rib.
- Advance with the tube into the pleural space in the correct position (cephalically in the case of pneumothorax and caudally in the case of haemothorax) and simultaneously remove the metal introducer needle.
- Observe how the tube and air inlet and outlet are fogged with breathing movements.
- Connect the tube to the water seal or Heimlich valve after checking that the valve is not connected upside down.
- Fix the tube by means of subcutaneous stitches in a purse-string suture with 2/0 silk.
- Place a dressing of vaseline gauze and fix it with surgical tape together with the tube.
- Get a thorax x-ray as soon as possible.
- In clinical practice, drainage is usually limited to 1-1.5 litres, then the thoracic tube is clamped for 2-4 hours before further drainage if the patient has chest pain, shortness of breath or oxygen desaturation.

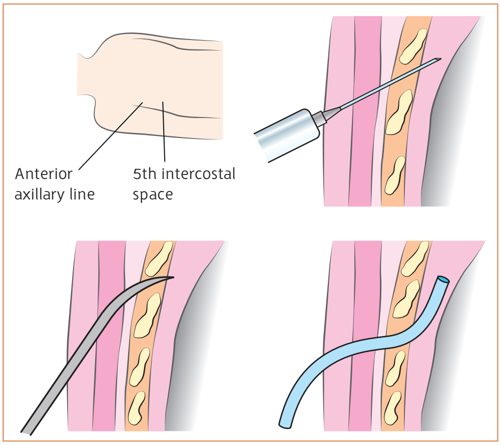

Figure 28.10. Thoracic tube drainage.

URGENT PERICARDIOCENTESIS

This technique should be performed in the hospital. Since defibrillators with electrocardiographic recording have been available in medical helicopters, some doctors have defended their practice in the event that the victim is dying, there is a high level of suspicion of cardiac tamponade, and the doctor is very skilled in performing this technique. It is described here as a reminder, keeping in mind all these details and precautions.

Indications

Cardiac tamponade.

Material

- Basic intubation and resuscitation equipment.
- Antiseptic.
- Gauze and surgical drapes.
- Sterile gloves.
- 16-18 G long catheter.
- Three-way tap.
- 50 mL syringe.
- Local anaesthesia and syringe and needle for infiltration.

Technique

- Administer oxygen.
- Position on stretcher at 45-55º.
- Infiltrate local anaesthesia below and to the left of the xiphoid appendix.
- Connect a 16-18 G catheter to a three-way tap and a 50 mL syringe.
- Continuous ECG recording. Suspecting cardiac penetration if extrasystole or ST elevation occurs.
- Left paraxymphoid approach with the needle angled 45° towards the inside of the left collarbone, moving gently forward and aspirating while the ECG is observed.

The blood that will be obtained from the pericardium will not clot.

Place a pair of Kocher forceps on the needle at the level of the skin surface to mark the level of penetration, in case it is necessary to repeat the procedure.

29 MEDICAL EQUIPMENT

A practical method to organize and sort the medical supplies is to think of the material needed for each step of the A-B-C-D-E method to the patient.

The following example can be used, adapting it for users and their circumstances.

Table 29.1. Method of equipping a first aid kit or backpack

A-B-C-D-E method	Rescue backpack
Protection	Nitrile gloves.
Airway (A)	Guedel cannula (laryngeal tube? Fastrach?). 50 - 100 cc syringe connected to probe for aspiration of secretions.
Respiration (B)	Mask and insufflation bag (oxygen bottle with pressure reducer and Monaghan type mask?).
Circulation (C)	20 × 40 gauze (4 packs) and large 45 × 45 gauze pads (1 or 2). Crepe bandages (1 of 7cm x 10 m and 1 of 10cm × 10m). Vaseline gauze 5.5 × 8 (Linitul® type = Duoderm®, Mesitran®). Adhesive stitches. Adhesive tape. Scalpel blades or scissors. Pelvic sling.
Neurological (D)	Glucose.
Exposure (E)	Rescue blanket 200 g. Mouldable splint. Dressing for blisters. Needle. Antiseptic (chlorhexidine in mono-dose). Analgesic: paracetamol 1 g. Anti-inflammatory: ibuprofen 600 mg. Antihistamine. Inhaled salbutamol. Sublingual solinitrina. Acetylsalicylic acid 500 mg. Amoxicillin with clavulanic acid 875/125 mg or ciprofloxacin 500 mg in case of penicillin allergy. Antidiarrheals: Loperamide. Antiemetics: Ondansetron. Anti-inflammatory eye drops - antibiotic. Minimum sun protection SPF 15. Water purification tablets (Micropur® type). Insect repellent.

MOUNTAIN FIRST AID KIT

There is widespread agreement on carrying a small first aid kit during mountain activities, but no agreement on what to carry in it.

Recommending a mountain first-aid kit is not easy, since if a very complete first-aid kit is recommended, it is most likely that the mountaineer will not carry it, so it is better to take a small first-aid kit with you, rather than a very complete one that you will probably leave in your car.[388]

It is recommended that each mountaineer designs the first aid kit according to his or her needs, taking into account a series of considerations:

- Weight and volume of the first aid kit.
- Duration of the mountain activity.
- Isolation of the area where the activity will be practiced.
- Possibility of improvising treatment material.
- Carry only what you know how to use.
- The container is as watertight as possible and can be placed in a freezer bag with an airtight seal.
- A good way to design a first-aid kit is to do it with the A-B-C approach to the injured person in mind: what to take for the A (airway), for the B (breathing), etc.

Without wishing to dogmatise, we suggest some ideas for excursions in our mountains that do not have high altitudes or tropical characteristics.

Personal first aid kit

A personal first aid kit of 45 g (plus 200 g for the thermal blanket) for a day trip could perhaps contain:

- 1 aluminised blanket of 200 g.
- 1 tablet of ibuprofen of 600 mg.
- 1 glucose tablet.
- 1 needle.
- 1 scalpel blade.
- 1 crepe bandage.
- 1 packet of sterile gauze 20 × 40.
- Duct tape or adhesive tape; it stands in for surgical tape, because it sticks even in very cold temperatures and is very useful even for repairing torn garments, etc.
- Mobile phone.

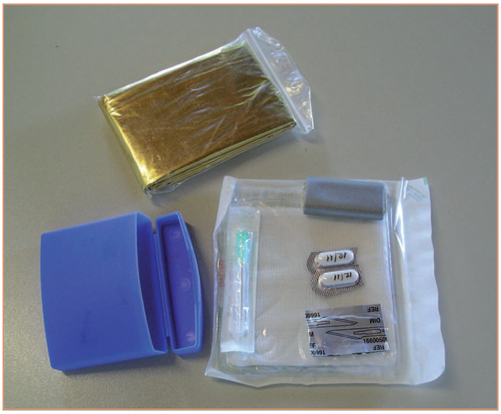

Figure 29.1. Micro first-aid kit.

First aid kit for mountaineering

A possible model of a 690 g first aid kit for longer excursions or for a mountain guide with accompanying customers would be:

- 1 Guedel cannula.
- Crepe bandages (1 of 7 cm × 10 m and 1 of
- 10 cm × 10 m).
- Mouldable splint (SAM splint® type).
- Vaseline gauze 5.5 × 8 (Linitul ® type = Duoderm®, Mesitran®).
- 20 × 40 gauze (4 packs) and large 45 × 45 gauze pads (1 or 2).
- Adhesive stitches (Steri-strips® type).
- Dressings for blisters (Compeed® type).
- Duct tape. It stands in for surgical tape and sticks even in very cold temperatures, it is very useful, even, for repairing torn garments, etc.
- Aluminised blanket of 200 g.
- Nitrile gloves.
- Scalpel blades (2).
- Needle.
- Antiseptic: in principle, wounds can be washed with drinkable water and it may be useful to carry a soapy sponge, which could save on povidone-iodine. If you want to carry it, and to avoid unpleasant accidents due to accidental spillage, it can be carried in ointment or in monodose bottles. Another option is chlorhexidine in monodose.
- Analgesic: paracetamol 1 g, acetylsalicylic acid 500 mg. Do not administer acetylsalicylic acid in cases of allergy or gastroduodenal ulcer or asthma.
- Anti-inflammatory: ibuprofen 600 mg. Do not administer in the case of a gastroduodenal ulcer.
- Antihistamine.
- Amoxicillin with clavulanic acid 875/125 mg or ciprofloxacin 500 mg in case of penicillin allergy. Administer 875/125 mg amoxicillin

with clavulanic acid or 500 mg of ciprofloxacin in case of an injury that cannot be treated for more than 6 hours. These antibiotics are also useful in other infections that can be suffered in the mountains (respiratory, urinary, otorhinolaryngological, etc.). Fluoroquinolones should be reserved for use in patients who have no alternative treatment options.
- Anti-diarroheals: loperamide: in case of diarrhoea, 2 tablets may be taken at the start, followed by one tablet after each diarrhoea stool, not exceeding 6 tablets per day.
- Antiemetics: ondansetron 4 mg, 1 tablet in case of nausea or vomiting.
- Anti-inflammatory / antibiotic eye drops.
- Glucose.
- Medication for regular personal use: remember to carry your regular personal medicines (allergy, migraine, haemorrhoids, heartburn, insulin, preloaded adrenaline, etc.).
- Instructions for use of the drugs.
- Pencil.
- Minimum sun protection SPF 15.
- Water purification tablets (Micropur ® type).
- Insect repellent.
- Ammonia pencil.
- Mobile phone.

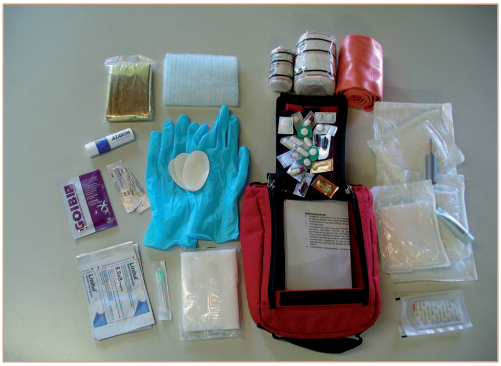

Figure 29.1. First-aid kit.

Professional first aid - backpack

A model of a first-aid kit for an organised mountain intervention group could be as follows:
- 4 pairs of nitrile gloves.
- 1 set of Guedel cannulae.
- 1 pocket mask.
- 4 small gauze packs.
- 4 large gauze packs.
- 2 vaseline gauze (Linitul® = Duoderm®, Mesitran®).
- 1 pack of adhesive dots.
- 2 bandages type crepe 7,5 cm × 4 m.
- 2 crepe bandages 10 cm × 4 m.
- 1 mouldable aluminium splint (SamSplint® type).
- 2 pieces of 50 cm each of Tubifix® nº 2 and nº 4.
- Light duct tape.
- 2 vials of physiological serum for irrigation of 10 mL.
- 1 vial of saline solution for irrigation of 50 mL.
- 1 hypodermic loading needle (20 G).
- 1 scalpel blade.
- 1 pair trauma scissors.
- 1 light thermal blanket (100 g).
- 1 heavy thermal blanket (Blizzard®).
- 1 complete sling.
- 1 «velcro» tape (ActimoveSling® type).
- Medication: indicated for own use.
    - Adiro (300 mg).
    - Ibuprofen (600 mg).
    - Paracetamol (1 g).
    - Ebastine (20 mg).
    - Terbutaline - Turbohaler inhaler.
    - Sublingual solinitrina.
    - Preloaded adrenaline.
    - 2 Povidone-iodine (single-dose).
    - 2 Chlorhexidine (single-dose).

RESCUE BACKPACK

The content of a rescue backpack is very variable.[389, 390] A possible model is as follows:

Ventilation

- 1 laryngoscope with 2 blades (adult and child).
- Adult (7.5, 8, 8.5) and child (5) orotracheal tubes.
- Syringe to inflate the endotracheal tube balloon.
- Fastening guide to insert the tube. Frova intubating introducer.
- Fastrach 3, 4, 5 laryngeal mask with tube.
- Laryngeal tube.
- Insufflation balloon with oxygen reservoir.

- Oropharyngeal cannula.
- Water-soluble lubricant.
- Oxygen bottle with pressure reducer.
- Suction system with suction probes of different sizes.
- Nasogastric tube.
- 1 catheter for cricothyroid puncture.
- Valved “T” adapter for ventilator.
- 10 mL syringe with intradermal needle.
- Kit for mini-tracheostomy.
- Pulse oximeter.

Thoracic drainage

- Trocar catheter.
- Thoracic tube 20-28 Fr.
- Seldinger type thoracic drainage.
- Heimlich valve.
- T-adapters.
- The Pleurecath® pleural puncture kit is less aggressive and easy to use in an emergency situation, despite its limited usefulness in case of massive hemothorax.

Surgical equipment

- Scalpel blade 10-11.
- Suture set: tweezers, scalpel handle, scissors, haemostatic tweezers, needle holders.
- Silk 1, 2/0.
- Sterile drapes (2).

Medical care

- Gauze (4 packs).
- Gauze pads (2).
- Vaseline gauze (Linitul® = Duoderm®, Mesitran®; Tulgrasum® = Aquacel®).
- Bandages (2 of 5 × 10).
- Surgical tape (2).
- Steritrips® type adhesive strips.
- Sterile gloves.

Perfusion

- Sterile catheters for children (10, 20, 21) and adults (12, 14, 16, 18).
- Long sterile catheter 14 G for pericardiocentesis.
- Intraosseous line.
- Adult (21 G) and child (23 G) winged infusion set.
- Infusion sets (2).
- Sphygmomanometer and stethoscope.
- Syringes 5, 10, 20 mL and one of 50 mL.
- IM and IV needles.
- 3-way valve.
- Physiological serum (4 litres).
- Physiological serum 250 mL.
- 20% NaCl Serum (14 vials).
- Needle container.

Traumatology

- Splints.
- Mouldable aluminium splint.
- Thread with straight needle.
- KED splint.
- Rescue blanket 200 g.

Drugs

Oral administration

- Paracetamol (1 g).
- Acetylsalicylic acid (500 mg).
- Ibuprofen (600 mg).
- Codeine (30 mg).
- Tramadol (50 mg).
- Diazepam (5-10 mg).
- Ondansetron (4 mg).
- Amoxicillin with clavulanic acid 875/125 mg (2 tabs).
- Ciprofloxacin 500 mg (2 tabs). Fluoroquinolones should be reserved for patients with no other treatment options.

Sublingual route

- Fentanyl.
- Tramadol (1 pulse = 5 drops = 12.5 mg).
- Diazepam (5-10 mg).
- Sublingual nitroglycerin.

Parenteral route

- Dexketoprofen (50 mg).
- Paracetamol IV (100 mL = 1 g).
- Ketamine (50 mg/mL, 10 mL vials = 500 mg of ketamine).
- Fentanyl (0.05 mg/mL 3 mL vials = 0.15 mg fentanyl) (5 vials).
- Atropine (1 mg) (3 vials).
- Diazepam 5-10 mg (5 vials).
- Midazolam (15 mg in 3 mL) (4 ampoules).
- Ondansetron (4 mg).
- Local anaesthesia (3 vials).

- Adrenaline (5 vials).
- Hydrocortisone 100 mg (3 vials).
- Urbason 40 mg (2 vials) (metilprednisolona).
- Amoxicillin with clavulanic acid 1 g (1 vials).
- Naloxone 0.4 mg (2 vials).
- Flumazenil (2 vials).
- Glucosmon 33% 10 mL (2 vials) (dextrose 33%).
- Polaramine (3 vials) (dexchlorpheniramine).

Intranasal inhaler

- Fentanyl.
- Salbutamol or terbutaline inhaler.

Semi-automatic defibrillator

BASIC TREATMENT MATERIAL

- Scalpel.
- Scalpel blades number 10, 11 and 15.
- Dissecting fine-pointed forceps (Adson) as well as broad-pointed.
- Haemostatic forceps (mosquito and Kocher).
- Needle holder.
- Syringes.
- Subcutaneous insulin needles (29 G), IM (21 G), IV (20 G).
- Adult (21 G) and child (23 G) butterflies.
- IV catheter (14, 16 G).
- Three way valve.
- Gauze 20 × 20.
- 50 × 50 gauze pads.
- Gauze bandages 5-10 cm.
- Elastic crepe bandage 5-10 cm.
- Cotton bandage 5-10 cm.
- Elastic adhesive bandage (Tensoplast®) 5-7.5-10 cm.
- Extendable tubular bandage (Tubiton®).
- Plaster bandages 5, 10, 15, 20 cm.
- Tubular bandage support mesh.
- Aluminium finger splint.
- Surgical tape.
- Sterile drapes.
- Vicryl sutures (3-4/0) and silk (1, 1/0, 2/0, 3/0, 3/0, 4/0, 5/0, 6/0).

STERILIZATION OF THE EQUIPMENT

Boil for 15 minutes.

Peracetic acid 0.2-0.3% for 10 minutes.

NORMAL DOSAGES, CONTRAINDICATIONS, PRECAUTIONS AND MOST NOTEWORTHY SIDE EFFECTS OF SOME DRUGS MENTIONED IN THE TEXT

All drugs can cause allergies!

Acetazolamide

Dosage: 125-250 mg every 8-12 hours.

Contraindications, precautions and most notable side effects: rare in treatments in the short term.

Acetylsalicylic acid

Dosage: 500 mg every 6-8-12 hours or on demand.

Contraindications, precautions and most notable side effects: allergy, gastroduodenal ulcer.

Fusidic acid

Dosage: 1 application 3 times a day for 7 days.

Contraindications, precautions and most important side effects: avoid contact with the eyes.

Actilyse (rTPA)

Dosage: weight <67 kg: 15 mg IV in bolus, followed by 0.75 mg/kg in 30 min and then 0.35 mg/kg in 60 min.

Weight >67 kg: 15 mg IV in bolus, followed by 50 mg in 30 min and then 35 mg in 60 min. Do not exceed 100 mg

Adjuvant treatment: bolus of 5000U IV sodium heparin and then maintain a continuous infusion of 1000U hour of heparin via IV for 48h.

Contraindications: generally, Actilyse® should not be administered to patients with known hypersensitivity to alteplase, gentamicin (a trace residue of the manufacturing process) or to any of the excipients.

As with all thrombolytic agents, and generally in all indications, Actilyse® should not be used in cases where there is a high risk of bleeding such as in case of:

- Significant bleeding disorder, current or within the past 6 months, known bleeding diathesis.
- Patients on treatment with oral anticoagulants, e.g. warfarin sodium (INR >1.3).
- History of central nervous system damage (neoplasia, aneurysm, intracranial or spinal cord surgery).

- History, evidence, or suspicion of intracranial haemorrhage, including subarachnoid haemorrhage.
- Severe or grave, obvious or recent bleeding.
- Recent traumatic or prolonged external cardiac massage (>2 minutes) in the last 10 days.
- Having given birth within the previous 10 days.
- Recent puncture of a non-compressible blood vessel (for example, subclavian or jugular vein).
- Uncontrolled severe high blood pressure.
- Endocarditis or bacterial pericarditis.
- Acute pancreatitis.
- Proven gastrointestinal ulcerative disease during the last 3 months.
- Severe liver disease, including liver failure, cirrhosis, portal hypertension (oesophageal varices), and active hepatitis.
- Major surgery or major trauma in the last 10 days (this includes any trauma associated with the current acute myocardial infarction).
- Recent trauma to the head or skull.
- Arterial aneurysms, artery/venous malformations.
- Neoplasms with increased risk of bleeding.
- Hypersensitivity to alteplase (rtPA) or any of the excipients.

Contraindications in patients with acute myocardial infarction (AMI) and pulmonary embolism

- Haemorrhagic vascular accident (haemorrhagic stroke) or cerebral vascular accident (cerebral stroke) of unknown origin at any time.
- Ischemic stroke or transient Ischemic attack (TIA) in the previous 6 months, except recent acute stroke within 4.5 hours.
- In the case of acute ischaemic stroke, the following contraindications are added to the above:
  - Symptoms of ischemic stroke that began more than 4.5 hours before the onset of infusion or when the time of onset of symptoms is unknown.
  - Symptoms of acute ischemic stroke that improved rapidly or were only minimal before the infusion began.
  - Severe stroke according to clinical evaluation (e.g. NIHSS >25) and/or appropriate imaging techniques.
  - Seizures at the onset of CVA (cerebral stroke).
  - History of previous stroke or severe head trauma within the last 3 months.
  - Combination of previous stroke and diabetes mellitus.
  - Heparin administration within 48 hours prior to stroke onset with an elevated partial thromboplastin activated (PTTa/KPTT) at time of onset.
  - Platelet count less than 100,000/mm^3.
  - Systolic blood pressure >185 or diastolic blood pressure >110 mm Hg, or need for aggressive management (IV medication) necessary to reduce blood pressure to these limits.
  - Blood sugar <50 or >400 mg/dL.
- Actilyse® is not indicated as therapy for ischemic CVD in children and adolescents under 18 years of age. For patients over the age of 80, see general precautions.

Secondary and adverse reactions

- The most frequent adverse reaction associated with Actilyse® is bleeding (bleeding >1:100, but only >1:10 is severe bleeding), resulting in a drop in haematocrit and/or haemoglobin values. Bleeding can occur in any site or body cavity, which can result in life-threatening or disabling situations, or in death. The types of bleeding associated with thrombolytic therapy can be divided into two broad categories:
  - Superficial bleeding, usually from venepuncture sites or in injured blood vessels.
  - Internal bleeding, anywhere in the body cavity.
- It may be associated with neurological symptoms of intracranial bleeding, such as drowsiness, aphasia, hemiparesis, and seizure.
- The risk of fatty embolism, which was not observed in the clinical trial population, was based on spontaneous reports.
- The number of patients treated in clinical studies for the indication of pulmonary embolism and ischemic CVD (within the win-

dow period of 0 to 4.5 hours) is very small compared to the number of patients in the myocardial infarction study. Therefore, the small numerical differences observed compared to the number in acute myocardial infarction were presumably attributed to the small sample size. With the exception of intracranial haemorrhage as an adverse reaction in the indication of ischemic CVD, as well as reperfusion arrhythmias in the indication of acute myocardial infarction (AMI), there are no medical reasons to assume that the quantitative and qualitative adverse reactions of Actilyse® in pulmonary embolism and acute ischemic CVD are different from the profile in the indication of AMI.

- Immune system disorders: anaphylactoid reactions, which are usually mild but life-threatening in rare cases. There may be: rash, hives, bronchospasm, angioedema, hypotension, shock, or any other symptoms associated with hypersensitivity. If this happens, conventional allergy therapy should be started. In such cases, a high proportion of patients were concurrently receiving ACE inhibitors. There are no known definitive anaphylactic (IgE-mediated) reactions to Actilyse®. Transient formation of antibodies against Actilyse® has been observed in rare cases and with low titrations, but the clinical relevance of this finding cannot be established.
- Ophthalmological disorders: ocular haemorrhage.
- Cardiac disorders: pericardial haemorrhage.
- Vascular disorders: haemorrhage (such as hematoma) Embolism, which can lead to corresponding consequences in affected organs. Haemorrhaging from parenchymal organs such as hepatic or pulmonary haemorrhage.
- Respiratory, thoracic and mediastinal disorders: respiratory tract haemorrhage such as pharyngeal haemorrhage, haemoptysis, epistaxis.
- Gastrointestinal disorders: gastrointestinal haemorrhage such as gastric bleeding, haemorrhaging gastric ulcer, rectal haemorrhage, hematemesis, melena, buccal haemorrhage, gingival bleeding: retroperitoneal haemorrhage, such as retroperitoneal haematoma; nausea and vomiting. Nausea and vomiting may also occur as symptoms of myocardial infarction.
- Skin and subcutaneous cellular tissue disorders: ecchymosis.
- Renal and urinary tract disorders: Urogenital haemorrhage, such as haematuria, haemorrhage of the urinary tract.
- General disorders and conditions at the site of administration: haemorrhaging at the injection site, haemorrhaging at the puncture site including hematoma, and haemorrhaging at the catheter site.
- Investigations: decreased blood pressure and increased body temperature.
- Wounds, intoxication and complications from the procedure: fat embolism, with its corresponding consequences in the affected organ.
- Medical and surgical procedures.
- Blood transfusion.
- **Acute myocardial infarction.**
- Cardiac disorders: reperfusion arrhythmias; such as arrhythmia, extra systoles, atrial fibrillation, first-degree atrioventricular block to complete atrioventricular block, bradycardia, tachycardia, ventricular arrhythmia, ventricular fibrillation, ventricular tachycardia; occur in a very close relationship under treatment with Actilyse®. Impact arrhythmias can lead to life-threatening cardiac arrest and may require the use of conventional antiarrhythmic therapies.

Indications in myocardial infarction and pulmonary embolism

- Nervous system disorders: intracranial haemorrhaging such as cerebral haemorrhage, cerebral hematoma, haemorrhagic cerebral vascular accident, haemorrhagic transformation of cerebral vascular accident, intracranial hematoma and subarachnoid haemorrhage.

Indication in acute ischaemic cerebral vascular accident

- Nervous system disorders: intracranial haemorrhaging, such as cerebral haemorrhage, cerebral hematoma, haemorrhagic cerebral vascular accident, haemorrhagic transformation of a cerebral vascular accident, intracranial hematoma and subarachnoid haemorrhage. Symptomatic intracerebral haemorrhages represent a major adverse event (up to 10% of patients).

Amiodarone

Dosage: two alternatives for acute treatment:

- Perfusion IV. Initial or attack dose: usual dose 5 mg/kg (in 250 mL of 5% dextrose), over a period of 20 min to 2 h. Repeatable from 2 to 3 times in 24 h, adjust speed according to response. The action manifests itself from 1 min onwards and gradually diminishes. Maintenance dose: 10 to 20 mg/kg/24 h (600-800 mg/24 h, limit 1,200 mg/24 h) in 250 mL of 5% dextrose for a number of days.
- Injection IV (rapid response): 5 mg/kg (injection duration should not be <3 min).

Cardiopulmonary resuscitation in the treatment of defibrillation-resistant ventricular fibrillation: initial dose IV 300 mg (or 5 mg/kg) diluted in 20 mL of 5% dextrose and injected rapidly. Consider an additional IV dose of 150 mg (or 2.5 mg/kg) if ventricular fibrillation persists.

Contraindications, precautions and most notable side effects: Hypersensitivity to iodine or tincture of iodine or amiodarone; sinus bradycardia, sinus-atrial blockage; atrioventricular blockage; sinus disease without pacemaker implantation (risk of sinus arrest); severe atrioventricular conduction disorders in patients without pacemakers or in ICUs and under ECG monitoring; thyroid function disorders; association with drugs that induce torsade de points; pregnancy (except in special circumstances); lactation. In addition, in IV: severe arterial hypotension, cardiovascular collapse, hypotension, severe respiratory failure, cardiomyopathy or heart failure.

Amoxicillin

Dosage: 500-1,000 mg every 8 hours.

Contraindications, precautions and most notable side effects: mild gastrointestinal disorders.

Amoxicillin with clavulanic acid:

Dosage: 500/125 mg every 8 hours or 875/125 mg every 12 hours.

Contraindications, precautions and most notable side effects: diarrhoea and other mild gastrointestinal disorders.

Atropine

Dosage, contraindications, precautions and most important side effects: see Chapter 13.

Aureomycin eye drops

Dosage: 1-2 drops every 2 hours in each eye.

Aureomycin eye ointment

Dosage: 1 application per night in each eye.

Azelastine

Dosage: 1 drop in each eye every 12 hours / 1 application in each nostril every 12 hours.

Methylene blue

Dosage, contraindications, precautions and most important side effects: see Chapter 13.

Budesonide

Dosage: 2 nebulisations every 24 hours in each nostril every morning.

Contraindications, precautions and most notable side effects: local effects (sneezing, nosebleeds, etc.).

Carbamazepine

Dosage: 200 mg every 8 hours.

Contraindications, precautions and most notable side effects: drowsiness, gastrointestinal symptoms.

Cefotaxime

Dosage: see “Appendicitis”.

Contraindications, precautions and most notable side effects: allergy, blood dyscrasias.

Cetirizine

Dosage: 1 tablet per day.

Contraindications, precautions and most notable side effects: modest drowsiness.

Ciprofloxacin

Dosage: 250-500-750 mg every 12 hours.

Contraindications, precautions and most notable side effects: exercise caution with epileptics, gastrointestinal disorders, dizziness, headache, tachycardia. Fluoroquinolones should be reserved for patients who have no alternative treatment options.

Ciprofloxacin topical ophthalmologic

Dosage: 1 drop every 3 hours. Ointment 3-4 times a day or at night, associated with daytime eye drops.

Contraindications, precautions and most notable side effects: allergy to the compound.

Ciprofloxacin topical otic

Dosage: 4-6 drops every 6-8 hours, or 1 single dose pack every 12 hours for 7-10 days.

Contraindications, precautions and most notable side effects: itching.

Clarithromycin

Dosage: 250-500 mg every 12 hours.

Contraindications, precautions and most notable side effects: gastrointestinal disorders, headaches.

Clindamycin

Dosage: 150-450 mg every 6 hours.

Contraindications, precautions and most notable side effects: diarrhoea.

Chlorpheniramine

Dosage: 5 mg IV or deep IM.

Contraindications, precautions and most notable side effects: drowsiness.

Codeine

Dosage: 30 mg every 6 hours.

Contraindications, precautions and most notable side effects: constipation.

Dexchlorpheniramine

Dosage: 2-6 mg every 6-12 hours.

Contraindications, precautions and most notable side effects: drowsiness.

Dexamethasone

Dosage: 8 mg to begin with; followed by 4 mg every 6 hours IM.

Contraindications, precautions and most notable side effects: gastroduodenal ulcer, diabetes.

Diazepam

Dosage: 5-10 mg.

Contraindications, precautions and most notable side effects: drowsiness, respiratory depression.

Diclofenac

Dosage: 50-75 mg.

Contraindications, precautions and most notable side effects: gastroduodenal ulcer.

Diclofenac ointment

Dosage: 1 application 3 times a day.

Contraindications, precautions and most notable side effects: allergy to the compound.

Diphenhydramine

Dosage: 25 mg.

Contraindications, precautions and most notable side effects: drowsiness.

Dopamine

Dosage, contraindications, precautions and main side effects: see “shock”.

Doxycycline

Dosage: 1 each day.

Contraindications, precautions and most notable side effects: photosensitivity.

Ebastine

Dosage: 1 each day.

Contraindications, precautions and most notable side effects: rarely, headache.

Erythromycin

Dosage: 500 mg every 6 h.

Contraindications, precautions and most notable side effects: allergy to the compound.

Fentanyl

Dosage, contraindications, precautions and most important side effects: see "Analgesia and sedation".

Formoterol

Dosage: 1-2 applications every 12 hours.

Contraindications, precautions and most noticeable side effects: tachycardia, tremors.

Fluticasone

Dosage: 2 nebulisations every 24 hours in each nostril every morning.

Contraindications, precautions and most notable side effects: local effects (sneezing, nosebleeds, etc.).

Glycopyrrolate

Dosage, contraindications, precautions and most important side effects: see "Mushroom poisoning".

Hydrocortisone 1%

Dosage: 1-3 applications per day.

Contraindications, precautions and most notable side effects: herpes, burns, frostbite. Avoid contact with eyes.

Hyoscine butylbromide

Dosage: 1-2 tablets, 3-5 times daily.

Contraindications, precautions and most noticeable side effects: rarely, dry mouth and tachycardia.

Ibuprofen

Dosage: 400-600 mg every 6-8-12 hours.

Contraindications, precautions and most notable side effects: gastroduodenal ulcer.

Iloprost

Dosage: dilute 1 vial 0.5 mL with 24.5 mL NaCl 9%. Syringe pump: 1 mL/h for 30 min, followed by 2 mL/h for 30 min, followed by 3 mL/h for 30 min, followed by 4 mL/h if weight <75 kg or 5 mL/h if weight >75 kg. Continue until 25 mL are administered; all patients receive 1 vial. Monitor BP and heart rate.

If side effects or systolic pressure <90 mmHg, reduce to previous dose.

This dose may be repeated every day for 3 days.

Precautions: anticipate nausea and vomiting, pain, hypotension. Keep the patient in the supine position.

Contraindications, precautions and most notable side effects: hypotension, hypersensitivity; pathologies with risk of bleeding (active peptic ulcer, trauma, intracranial bleeding); severe coronary heart disease or unstable angina; MI in the previous 6 months; decompensated heart failure; severe arrhythmias; cerebrovascular episodes (e.g. TIA, stroke) in the previous 3 months; pulmonary hypertension due to veno-occlusive disease; valvular diseases with significant alterations in myocardial function not related to pulmonary hypertension.

Ketamine

Dosage, contraindications, precautions and most important side effects: see Chapter 17.

Levofloxacin

Dosage: 1 tablet per day for 7-10 days.

Contraindications, precautions and most notable side effects: exercise caution with epileptics, gastrointestinal disorders, dizziness, headache and tachycardia.

Levocabastine

Dosage: 1 drop in each eye every 12 hours. 2 applications in each nostril every 12 hours.

Loperamide

Dosage: 2 tablets of entry followed by 1 after each diarrhoeal stool up to a maximum of 8 a day.

Contraindications, precautions and most notable side effects: gastrointestinal disorders.

Loratadine

Dosage: 1 each day.

Contraindications, precautions and most notable side effects: drowsiness.

Methylprednisolone

Dosage: 0.5-1 mg/kg by weight.

Contraindications, precautions and most notable side effects: gastroduodenal ulcer, diabetes.

Midazolam

Dosage, contraindications, precautions and most important side effects: see "Orotracheal intubation".

Morphine

Dosage, contraindications, precautions and most important side effects: see Chapter 17.

Mupirocin

Dosage: 1 application 3 times a day.

N-acetylcysteine

Dosage, contraindications, precautions and most important side effects: see "Mushroom poisoning".

Nifedipine

Dosage: from 10 mg every 4-6 hours to 30 mg every 8-12 hours, not exceeding 90-120 mg/day.

Contraindications, precautions and most noticeable side effects: hypotension, headache, flushing, dizziness, palpitations, nausea, angina pain.

Nitrites

Dosage: 1 puff or 1 sublingual tablet without pain.

Contraindications, precautions and most notable side effects: hypotension, dizziness, headache.

Ofloxacin

Dosage: see "Appendicitis".

Contraindications, precautions and most notable side effects: exercise caution with epileptics, gastrointestinal disorders, dizziness, headache, tachycardia.

Omeprazole

Dosage: 1 per day.

Contraindications, precautions and most notable side effects: headache, hives, muscle pain.

Ondansetron

Dosage, contraindications, precautions and most important side effects: see "Mushroom poisoning".

Oxybuprocaine

Dosage: 1-2 drops several times a day.

Contraindications, precautions and most notable side effects: irritation.

Paracetamol

Dosage: 500 mg every 4-6 hours.

Contraindications, precautions and most notable side effects: hepatotoxicity at very high doses.

Penicillin G sodium

Dosage, contraindications, precautions and most important side effects: see Chapter 13.

Penicillin G benzathine

Dosage: 1 IM injection.

Contraindications, precautions and most notable side effects: pain at the injection site.

Physostigmine

Dosage, contraindications, precautions and most important side effects: see "Intoxication by plants".

Pyridoxine

Dosage, contraindications, precautions and most important side effects: see Chapter 13.

Racecadotril

Dosage: 100 mg (one tablet) every 8 hours

Contraindications, precautions and most important side effects: allergy

Ranitidine

Dosage: 300 mg daily.

Contraindications, precautions and most notable side effects: hepatitis.

Rocuronio

Dosage, contraindications, precautions and most important side effects: see "Orotracheal intubation".

Rizatriptan

Dosage: see “Migraine”.

Contraindications, precautions and most noticeable side effects: dizziness, drowsiness, fatigue.

Salbutamol

Dosage: 2 inhalations in case of bronchospasm.

Contraindications, precautions and most noticeable side effects: tachycardia, tremor.

Silibinin

Dosage: 20 mg per kg of body weight per day, distributed in 4 IV infusions of 2 hours duration each and with 4 hours of interval between them, controlling the fluid balance.

Succinylcholine

Dosage, contraindications, precautions and most important side effects: see “Orotracheal intubation”.

Sulfadiacin silver

Dosage: 1 application every 24-48 hours.

Sumatriptan

Dosage: 50-100 mg oral or 20 mg nasal or 6 mg subcutaneously.

Contraindications, precautions and most notable side effects: contraindicated in cardiac ischemia.

Telithromycin

Dosage: 800 mg every day for 5 days.

Contraindications, precautions and most notable side effects: gastrointestinal disorders, headache, dizziness.

Terbinafine

Dosage: 1 application every 12-24 hours.

Terbutaline

Dosage: 2 inhalations in case of bronchospasm.

Contraindications, precautions and most noticeable side effects: tachycardia, tremor.

Tinidazole

Dosage: see “appendicitis”.

Contraindications, precautions and most noticeable side effects: gastrointestinal symptoms, leukopenia, thrombocytopenia, dark urine, disulfiram effect (avoid alcohol).

Tramadol

Dosage: 50-100 mg every 6-8 hours.

Contraindications, precautions and most noticeable side effects: dizziness, vertigo, nausea or vomiting, sweating, postural hypotension.

Triamcinolone

Dosage: 2 nebulisations every 24 hours in each nostril every morning.

Contraindications, precautions and most notable side effects: local effects (sneezing, nosebleeds, etc.).

Zolmitriptan

Dosage: see “migraine”.

Contraindications, precautions and most notable side effects: dizziness.

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GLOSSARY

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A

Abdomen: body cavity containing most of the viscera of the digestive and genitourinary system.
Abduction: a movement in which a limb moves away from the medial plane of the body to the side.
Abrasion: superficial wound on the skin.
Abscess: collection of pus due to infection of the tissue.
Acidosis: an abnormally acidic blood condition that may be due to metabolic or accidental hypothermia; alteration of the body's acid-base balance with a predominance of anions.
Acromion: upper process of the scapula (shoulder blade).
Acute: 1) that appears or persists for a short period of time; 2) that requires urgent attention.
Acute cholecystitis: inflammation of the gallbladder.
Acute hepatitis: inflammation of the liver.
Acute salpingitis: inflammation of the uterine tubes.
Adduction: movement by which a limb approaches the medial plane of the body, toward the centre.
Adenopathy: pathological enlargement of the lymph nodes.
Aerobic resistance: when the work intensity is not very high, the transport system provides enough oxygen to maintain this intensity for more than 30 minutes, thanks to the energy produced by the breakdown of fatty acids and glycogen stored in the liver.
Alkalosis: alteration of the acid-base balance of the body with a predominance of cations.
Alveoli: small air sacs in the lungs in which blood gas (oxygen and carbon dioxide) exchange occurs.
Anaerobic resistance: when the work intensity is very high, the transport system is not able to provide enough oxygen for aerobic glycolysis to function, and energy is produced through the degradation of the glycogen stored in the muscle itself, producing lactic acid. This system produces less energy than aerobic energy and stores lactic acid in the body.
Analgesia: pain relief.
Anamnesis: medical history.
Anaphylactic shock: shock from anaphylaxis.
Anaphylaxis: severe allergic reaction.
Angina pectoris: chest pain caused by a momentary lack of blood in one area of the heart muscle.
Anhidrosis: absence of sweating.
Anion: negatively charged ion.
Anisocoria: differing pupil size.
Arrhythmia: heart rhythm disorder.
Arteriography: radiological examination of the arteries with contrast.
Arthropod: an invertebrate animal with an articulated exoskeleton and even hinged legs. Includes arachnids and insects.
Asthma: a condition caused by the spasmodic contraction of the bronchi that causes choking.
Asystole: cardiac arrest.
AVD: avalanche victim location device.

B

Blood volume: the quantity of blood in the body.
Bradycardia: slow pulse.
Brain oedema: excessive fluid accumulation in the brain.
Bronchodilator: drug that dilates the bronchi.
Bronchospasm: narrowing of the bronchi.

C

Calorie: the heat needed to increase the temperature of one gram of water from 14.5 ºC to 15.5 ºC.

Capillaries: blood vessels where oxygen is exchanged from the blood into the tissues, and carbon dioxide from the tissues into the blood. They lie between the venous and arterial areas.

Carbohydrates: sugars.

Cardiac tamponade: acute compression of the heart due to blood from a heart rupture pooling in the pericardium.

Catheter: a tube inserted into an organ or structure inside the body.

Cation: positively charged ion.

Cephalalgia: headache.

Cerebral vascular accident (stroke): death of brain tissue due to haemorrhage or arterial obstruction; cerebral vascular disorder leading to the disruption of brain functions and a certain degree of muscular paralysis.

Clavicle: bone in the front of the chest between the breastbone and the shoulder blade.

Condyle: joint process of a bone.

Conjunctiva: a thin membrane covering the white, visible surface of the eye and the inside of the eyelids.

Conjunctivitis: inflammation of the conjunctiva.

Contusion: bruising.

Cornea: the transparent front part of the eye that covers the iris and pupil.

Cricothyroid: the area between the thyroid cartilage (Adam's apple) and the cartilage ring (cricoid) just below it.

Cricothyroidotomy: surgical opening of the cricothyroid membrane to allow air to enter the trachea in case of airway obstruction above this site.

Cyanosis: bluish colour of skin, lips, or nails due to lack of oxygen.

D

Debridement: the removal of foreign material and dead tissue from a wound.

Decubitus: lying position.

Defibrillator: device used to reverse ventricular fibrillation.

Dehydration: the loss of an excessive amount of water from the body.

Deltoid: muscle joining the arm to the shoulder.

Diabetes mellitus: a metabolic disease that manifests itself mainly in disorders of carbohydrate metabolism.

Diaphragm: dome-shaped muscle that separates the chest from the abdomen.

Diaphysis: middle part of the long bones.

Diptera: an insect that has only two wings (e.g. a mosquito).

Distal: farthest part of the body.

Diverticulitis: Inflammation of a diverticulum.

Diverticulum: a pouch that is sometimes produced in the colon.

Doppler echocardiography: ultrasound scan.

Dyspepsia: difficult and laborious digestion of a chronic nature.

Dyspnoea: shortness of breath.

Dysuria: itching when urinating.

E

Ecchymosis: extravasation of blood inside the tissues resulting in bluish discoloration.

Electrolyte: a substance dissolved in an ionised solvent that dissociates into ions. The four main ions in serum are sodium, potassium, chloride, and bicarbonate.

Endothelium: tissue surrounding the heart, blood and lymph vessels, and synovial cavities.

Enzyme: substance capable of accelerating or causing certain chemical changes.

Epilepsy: a neurological disorder characterised by repeated seizures.

Epistaxis: nosebleed.

Erythema: redness of the skin.

Esophagitis: inflammation of the oesophagus.

Esophagus: tube that carries food from the mouth to the stomach.

Exacerbation: an increase or an exaggeration in the severity of a symptom or illness.

Extracorporeal circulation: a technique in which part or all of the blood circulation is derived from outside the body. The individual's cardiopulmonary system is usually replaced by an artificial heart-lung device.

F

Femoral artery: large artery that runs down the muscle parallel to the femur.

Fibula: bone on the outside of the leg, next to the tibia.
Folliculitis: infection of the skin's hair roots.

G

Gastric lavage: irrigation of the stomach with serum.
Gastroduodenal ulcer: peptic ulcer disease.
Gastroenteritis: inflammation of the stomach and intestines.
Glasgow scale: test to measure the level of consciousness.
Glenoid cavity: cavity in the scapula where the head of the humerus is articulated.
Glucosides: sugars.
Glycogen: a form of glucose storage.

H

Hematoma: blood clotted inside of tissue.
Haematuria: bloody urine.
Hemoperitoneum: blood in the peritoneum.
Haemoptysis: bloody sputum.
Hemothorax: occupation of the pleural space by blood.
Hexapods: six-legged insect.
Humerus: bone that forms the skeleton of the arm.
Hymenoptera: insect with two pairs of wings and strong jaws (e.g. bee, wasp).
Hyperglycaemia: increased blood sugar.
Hyperhidrosis: profuse sweating.
Hyperkalemia: increased potassium in the blood.
Hypertension: high blood pressure.
Hyperthermia: dangerous increase in body temperature.
Hypoglycaemia: lowered blood sugar.
Hypotension: lowered blood pressure.
Hypothermia: lowering the body's core temperature to levels where muscle and brain functions are not working properly.
Hypovolaemia: decreased blood volume.
Hypoxemia: decreased oxygen in the blood.
Hypoxia: decreased oxygen in the tissues.

I

Immunosuppression: diminished immune system.
Infarction: death of tissue due to arterial obstruction.
Ion: atom or group of atoms into which electrolyte molecules are broken down.
Ischemia: reduced blood flow.
Ischemic heart disease: heart disease caused by an imbalance between the supply of oxygen by the coronary arteries and the needs of the myocardium.

J

Jaundice: yellowish skin due to the accumulation of bile pigments in the blood, almost always due to liver disease.

K

Keratitis: inflammation of the cornea of the eye.
Keratoconjunctivitis: inflammation of the cornea and conjunctiva.

L

Laryngoscopy: visualization of the larynx.
Lipids: fats.
Lumbago: low back pain.
Luxation: a complete loss of coherence between joint surfaces.

M

Medial epicondyle: a rounded protuberance of the lower inner part of the humerus.
Mediastinum: the middle space of the thoracic cavity, between the two pleura and the lung masses on the sides, the spine at the back, the sternum-costal plane at the front, the base of the neck at the top and the diaphragm at the bottom.
Melaena: black stools due to them containing blood.
Meniscus: interarticular fibrocartilaginous cushion.
Mesenteric ischemia: necrosis of an intestinal area.
Metacarpus: bones of the hand between the carpus and the fingers.
Metatarsus: bones of the foot between the tarsus and the toes.
Mydriasis: dilation of the pupil.
Mitochondria: cellular organelle where energy is produced.

Mycosis: skin disease caused by fungi.
Myocardial infarction: necrosis of an area of the myocardium, usually due to thrombosis of a coronary artery.
Myocardium: heart muscle, heart.
Miosis: contraction of the pupil.
Myriapods: arthropods characterised by a body formed from a variable number of segments with one or two pairs of legs per segment.

N

Necrosis: dead tissue.

O

Oedema: excessive fluid accumulation.
Olecranon: bony process located in the upper extremity of the ulna, forming the elbow.
Oligoanuria: scarce urine.
Osteoporosis: reduction in bone volume.
Otalgia: ear pain.
Otitis: inflammation of the ear.
Otorrhagia: blood coming out of the ear.
Oxidising radicals: group of atoms derived from a hydrocarbon; in the context of this book, inflammatory mediators in freezing.

P

Pancreas: gland in the abdomen.
Pancreatitis: inflammation of the pancreas.
Paralytic ileus: paralysis of the intestine, almost always due to peritonitis.
Paraesthesia: tingling, tickling, pricking, numbness or burning sensation in the skin.
Patella or kneecap: bone of the knee.
Pelvic girdle: bone ring made up of the iliac and sacral bones that support the lower limbs.
Pericardiocentesis: evacuating puncture of the pericardium.
Pericarditis: inflammation of the pericardium.
Pericardium: membrane surrounding the heart.
Peritoneal lavage: irrigation of the peritoneum with serum.
Peritoneum: membrane that lines the abdominal cavity and the external surface of the abdominal viscera.
Peritonitis: inflammation of the peritoneum.
Phalange: small bones of the fingers or toes.
Pharyngitis and tonsillitis: inflammation of the pharynx and tonsils.
Pleura: a thin membrane that envelops the lungs (visceral pleura) and the inside of the rib cage (parietal pleura) to maintain internal pressure.
Pleural lavage: irrigation of the pleural space with serum.
Pneumonia: infection of the lung.
Pneumothorax: air entering the pleural space, causing partial or complete lung collapse.
Pollakiuria: a desire to urinate often, which persists even after urination.
Polytraumatised: injured person with at least two serious traumatic injuries, with repercussions for one or more vital functions.
Popliteal: area of the leg behind the knee.
Process: a bone eminence.
Pronation: movement of the forearm that results in a rotation of the hand from the outside inwards, with the palm of the hand facing inward and backward.
Prophylaxis: prevention.
Prostaglandin F2: fatty acid; in the context used in this book, inflammatory mediator in freezing.
Protides: proteins.
Proximal: part closest to the body.
Pulmonary oedema: excessive fluid accumulation in the lungs.
Pulse oximeter: apparatus that measures oxygen saturation.
Purpura: haemorrhagic spots on the skin.

R

Radius: bone on the outside of the forearm, next to the ulna.
Reduction: restoration of the normal anatomical position in the case of a dislocation or a displaced complete fracture.
Retina: inner layer of the eyeball whose mission is the perception of radiant energy.
Retinopathy: damage to the eye's retina.

S

Scaphoid: wrist bone.
Scapula: bone forming the back of the shoulder.
Sciatic nerve: nerve passing through the lumbar region, back of the thigh, popliteal fossa, leg and foot.

Seizures: movements produced by intense muscle contractions in an unconscious patient as a result of disordered brain electrical activity.
Shock: an alteration in circulation that reduces the flow of blood to the tissues, causing cellular injury.
Shoulder girdle: bone ring made up of the clavicle and the scapula that supports the upper limb.
Sign: objective manifestation of a disease.
Sling: strap or bandage resting on the neck to support the injured hand, forearm, or shoulder, or to immobilise them.
Spasm: involuntary muscle contraction.
Spinal cord: part of the central nervous system that begins at the base of the brain and descends through the spinal column.
Sprain: an incomplete tear of a ligament or complex of ligaments responsible for the stability of a joint. It also applies to an incomplete rupture of muscles or tendons.
Stress fracture: complete very fine fractures.
Styloid: elongated bone eminence.
Subcutaneous emphysema: air that crackles under the skin.
Subdural hematoma: blood between the skull and brain, specifically between two of the layers of tissue surrounding the brain (dura mater and arachnoid).
Subluxation: joint surfaces are not congruent, but loss of contact is not complete.
Supine decubitus: lying on one' s back.
Symptom: subjective manifestation of a disease.
Syncope (fainting): loss of consciousness.
Syndrome: a series of signs and symptoms that exist at the same time and clinically define a given pathological state.

T

Tachycardia: rapid pulse.
Tachypnea: rapid breathing.
Tendonitis: inflammation of a tendon.
Thenar eminence: radial part of the palm of the hand.
Thermoregulation: regulation of body temperature.
Thoracentesis: a puncture of the chest wall, usually to remove air or fluid from the pleural space.
Thoracotomy: surgical incision in the chest wall.
Thromboembolism: embolism caused by a thrombus.
Thrombosis: formation of thrombus in the blood vessels.
Thromboxane A2: compound derived from prostanoic acid; in the context of the book, inflammatory mediator in freezing.
Thrombus: blood clot.
Tissular: of the tissue.
Tracheobronchitis: inflammation of the trachea and bronchi.
Trochanter: bony eminences located below the neck of the femur.
Trochlea: anatomical structure resembling a pulley.

U

Ulna: longer, inner bone of the forearm.
Urticaria (hives): pinkish papules accompanied by itching, usually from an allergic cause.

V

Valgus: turned outwards.
Varus: turned inwards.
Vasoconstriction: narrowing of the blood vessels.
Vasodilatation: dilation of the blood vessels.
Venous stasis: stagnation of blood in the veins.
Vertigo: a disturbance of balance that produces the sensation that one's self or the environment is spinning, is not synonymous with dizziness.

W

Wheezing: whistling sounds that the lung produces while breathing when there is a spasm of the bronchi.

INDEX

INDEX

A

Abdominal pain, 273
Abdominal trauma, 207
Abrasions, 244
Accident/s, 153-158
Acclimatisation, 108
Acetaminophen (see *Paracetamol*)
Acetazolamide, 109, 309
Acetylsalicylic acid, 309
Aconitum, 123
Acute abdominal pain, 275
Acute appendicitis, 275
Acute cholecystitis, 274
Aerobic resistance, 46
Altitude/s, 105
Amanita, 133
Amoxicillin, 312
Anaerobic resistance, 46
Anal fissures, 276
Anaphylactic shock, 290
Anaphylaxis, 290
Angina pectoris, 272
Anxiety, 287
Arachnid/s, 117
Arrhythmia/s, 149
Arthropod/s, 112
Aspiration, 149
Asthma, 279
Asystole, 145
Athlete's foot, 288
Atropa belladona, 124
Aureomycin, 312
Avalanche/s, 257
—warning bulletin, 259
AVD, 259

B

Back pain, 288
Balance, 284
Bandage, 216, 247
Bat, 112
Bee/s, 112
Bites, 119
Black widow, 117
Blisters, 243
Breathing, 141
Breathlessness, 279
Bronchitis (see *Tracheobronchitis*), 279
Bryonia dioica, 125
Burn/s, 249
—sunburn, 93

C

Calorie/s, 15
Carbohydrates, 18
Cardiac tamponade, 207
Cardio-respiratory resuscitation (CPR), 143
Cerebral oedema, 107
Cervical collar, 165
Cetirizine, 312
Chest pain, 202, 271
Chlorpheniramine, 313
Choking, 152
Ciprofloxacin, 313
Clarithromycin, 313
Clindamycin, 313
Clitocybe, 133
Codeine, 313
Cold, 61-86
—common (*cold*), 279
Colic, 274, 288
— hepatic, 274
— nephritic, 288

Coma, 286
Conduction, 58
Conium maculatum, 126
Conjuntivitis, 281
Contusions, 243
Convection, 58
Coordination, 193
Coriaria myrtifolia, 126
Coronary pain, 272
Cough, 203
Cramps, 215
— muscular, 215
— heat , 88
Cranioencephalic trauma, 193
Cricothyroid puncture, 298
Cricothyroidotomy, 289

D

Daphne mezereum, 127
Datura stramonium, 128
Defibrillator, 147
Dehydration, 24
Dental abscess, 282
Diazepam, 313
Diclofenac, 313
Diet, 16
Diphenhydramine, 313
Dipterans, 112
Diverticulitis, 274
Doxycycline, 313
Dressing/s (see also *Bandage*), 247
Drowning, 252
Dryness, 92
Dyspnoea, 202, 279

E

Earache, 283
Ebastine, 313
Edema, 215
Electrolytes, 24
English ivy, 128
Epilepsy, 291
Epistaxis, 284
Erythema solar, 93
Esophagitis, 271
Evaporation, 58

F

Fainting (see *Syncope*)
Fatigue, 52
Fever, 277
Fissure (see *Hairline fracture*)
Flexibility, 49
Fog, 102
Folliculitis, 288
Fracture/s, 211
Freezing (see *Frostbite*)
Frostbite, 77
Fusidic acid, 309

G

Gastroduodenal ulcer, 339
Gastroenteritis, 274
Glasgow Scale, 195
Glucose, 18-20
Glucoside/s, 18-20
Glycaemic index, 18
Glycogen, 18-20
Gyromitra, 135

H

Haemothorax, 206
Hairline fracture, 211
Harness hang syndrome, 191
Headache, 286
Heat, 87
—stroke, 89
Hedera helix, 128
Hemlock, 126
Hemorrhage, 187
Hemorrhoids, 277
Hepatitis , 274
Horsefly/horseflies, 112
Hydration, 23-25
Hydrocortisone , 314
Hymenoptera, 112
Hyoscine butylbromide, 312
Hyperglycaemia, 290
Hyperhidrosis, 58
Hyperkalemia, 69
Hyperthermia, 277
Hypoglycaemia, 290
Hypothermia, 61-76

Hypoxemia, 149
Hypoxia, 149

I

Ibuprofen, 314
Ice, 214
Immobilisation, 163-170
Immunosuppression, 337
Ingrown toenail, 244
Inocybe, 133
Insomnia, 104
Intestinal obstruction, 274
Ischemic heart disease, 272

J

Jimson weed, 128

K

Kendrick extrication device (Ferno-KED), 166
Keratitis, 108
Keratoconjunctivitis, 281

L

Lacerations, 244
Lepiota, 134
Levocabastine, 314
Lightning,
—bolt/s, 100
—strike/s, 100
Lipids, 21
Lipotimia, 285
Lonicera xylosteum, 129
Loperamide, 314
Loratadine, 314
Luxation, 214

M

Mesenteric infarction or angina, 273
Methylprednisolone, 314
Mezereon, 127
Migraine, 286
Minerals, 26
Moisture, 92
Mosquito, 112
Mountain sickness, 106
Mupirocin, 315
Mushrooms, 133-137
Mycosis, 92, 338
Myocardial infarction, 272
Myriapods, 338

N

Nerium oleander, 129
Nifedipine, 315
Nitrites, 315

O

Oropharyngeal cannula, 150
Orotracheal intubation, 293
Orthostatic hypotension, 285
Otalgia, 283
Otitis, 283
Oxygen, 149

P

Pain
—anal, 276
—ear (see *Earache, Otalgia*)
—low back, 288
—musculoskeletal, 271
Pancreatitis, 273
Paracetamol, 315
Penicillin, 315
Pericardiocentesis, 303
Pericarditis, 271
Pharyngitis , 283
Pharyngotonsillitis, 283
Physical preparation, 39-54
Plants, 123-131
Pneumonia, 279
Pneumothorax, 204
Polytraumatised, 153-161
Proteins, 20
Pulmonary contusion, 204
Pulmonary oedema, 107

R

Rabies, 112
Radiation, 93
Rays (UV/solar), 91-97
Relaxation, 49
Respiration (see *Breathing*)
Respirators, 151

Retinopathy, 290
Ricinus communis, 130

S

Salbutamol , 315
Scalds (see *Burns*)
Scolopendras, 119
Scoop stretcher, 165
Scorpions, 118
Scratches, 244
Shock, 187-192
Silibinin, 316
Skin cancer, 94-95
Snakes, 119
Speed, 49
Spiders, 117
Spinal board, 168
Spinal cord injury, 198
Sprain, 214
Stiffness, 215
Stitch (see *Suture*)
Strength, 48
Subconjunctival haemorrhage/s, 281
Subungual haematoma/s, 241
Sulfadiacin silver, 316
Sumatriptan, 316
Sun, 93
Suture, 246
Syncope, 285
—heat syncope, 89
—vasovagal syncope, 285

T

Tachycardia, 187
Tarantula, 117
Terbutaline, 316
Thermoregulation, 57
Thoracic trauma, 203
Ticks, 116
Tracheobronchitis, 279
Training, 39
Trench foot, 84

U

Unstable thorax, 204
Urinary tract infection, 288

V

Vacuum mattress, 166
Vasoconstriction, 58
Vasodilatation, 58
Vegetables, 123
Ventricular fibrillation, 147
Vertebral column trauma, 198
Vertigo, 284
Viper, 119
Vitamins, 27
Vomiting, 278

W

Wasp/s, 112
Water, 23
Water, 23
—purification, 36
Weather forecast, 59
Web pages of interest, 5, 6
White bryony, 125
Wind, 103
Wound/s, 244-246

Mountain and Wilderness Medicine

Evidence based

Enric Subirats Bayego

Mountain and wilderness medicine responds to the increasing need to provide health care for people far removed from health resources, often in a hostile environment. Recent changes in life style have boosted the interest in this discipline: diabetic hikers, cyclists with coronary stents…

The book coordinated by Enric Subirats encapsulates elements of emergency medicine, internal medicine, family medicine, sports medicine, orthopaedic surgery and traumatology, public health and travel medicine, so offering a practical manual to all those healthcare professionals whose work takes place in the natural environment: medical and health care personnel of ski resorts, mountain rescue groups and health professionals that carry out their activity in rural areas.

Some parts of the book are also useful to mountain first aid professionals (ski patrol and members of rescue groups), mountain professionals who occasionally need to participate in rescue tasks (mountain hut keepers, mountain guides, mountain instructors, ski instructors or outdoor activity monitors), and even to climbers of any level interested in having a reference book to broaden their knowledge of first aid in the mountains.

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